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Atomic Warfare and the Profession

IN their paper on the effects of atomic explosions on animals, reproduced in the special Congress Proceedings which accompany this issue, Dr. Loutit and Dr. Scott Russell draw attention to the vast size of the area in which radioactive fall-out occurred after the explosion of a nuclear weapon at Bikini on March 1st, 1954. The radioactivity in an area of 7,000 square miles was sufficiently intense to be lethal to mammals and there were dangerous, though perhaps not lethal, deposits of fission products in an even greater area round the periphery of the lethal zone. The nature of the fall-out pattern and the extent of the lethal and hazardous zones will vary with the circumstances of each nuclear explosion, and the long-term biological hazard from fall-out will be affected by the nature of the soil. But even allowing for such variables, it is clear that if only a relatively small number of weapons of a power similar to that of the Bikini bomb were to be exploded in this country at ground level, the effects on the country generally, and in particular on agriculture, would indeed be grave.

The median lethal doses for man and for farm animals fall within a fairly small range. In assessing the numbers of casualties likely to occur in man, and in animals, it must, however, be remembered that a great many human beings should be able to save their lives if public warning can be given of the approach of fall-out. Reasonable protection would be given by a large building with thick walls, by a cellar, or a previously prepared refuge room in a house. Farm animals in the main would not have adequate shelter nor might there be time to drive them in even if they had. Their losses from radiation from external sources would consequently be very much heavier than the casualties from fall-out to be expected amongst human beings who had had a warning of its approach ; grazing animals would also be exposed in a greater degree to the long-term hazard from ingestion of radioactive contamination of their food.

An approximate calculation—or perhaps a guess is a better word in view of all the uncertainties—suggests that losses of livestock from an attack with hydrogen bombs on this country would certainly amount to many hundreds of thousands of animals and might even be counted in millions. This estimate is reached after making allowances for overlapping of fall-out zones from more than one bomb, and for the deposition of a proportion of fall-out into the sea rather than on land, which is probably what would happen to fall-out from bombs exploded in this relatively narrow island.

Veterinary surgeons will ask how their particular skills and experience could best be used to serve the community in such a disaster. There would, of course, be local circumstances in which their duty would clearly be to assist in providing first-aid for human casualties. But it is unlikely to be in that way that the veterinary profession could make its most effective contribution in the struggle for survival. In the circumstances of a future war the need for food would be just as insistent as the need for medical care. It therefore seems reasonable to suppose that on farms affected by blast or fire, or contaminated by fall-out, an immediate and major responsibility of the profession in war-time would be to see that there was no avoidable waste of salvageable meat. Outside the fall-out area the profession would have to pay special attention to reserving suitable breeding stock with the object of safeguarding future supplies of milk and meat ; and to take steps to prevent or control the spread of animal disease. This latter task might be formidable in view of the reduced resistance to diseases of animals suffering from the effects of radioactivity and the difficulty of applying strict control methods in some of the affected areas. In short, the veterinary profession would have to use all its resources to ensure that food production, particularly milk and meat, was maintained at as high a level as possible. This would be of especial importance in the areas unaffected by fall-out, on which the nation would so largely depend.

Plans will, therefore, need to be made for the profession to take its part in deciding upon the edibility of meat from animals in the lethal and near-lethal zones which are suffering from the effects of radiation. In the less severely affected zones veterinary advice will be needed in deciding whether herds should be slaughtered or be kept alive to help to preserve a reservoir of

(*Continued on page* 932)

A Study of Reticulo-ruminal Motility in Adult Cattle in Relation to Bloat and Traumatic Reticulitis with an Account of the Latter Condition as seen in a General Practice*

BY

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PART II.—A Survey of Sixty-four Cases of Traumatic Reticulitis Diagnosed by the "Reticular Grunt" Method

BEFORE describing the new method of diagnosing traumatic reticulitis, reference is made to various aspects of the ailment as seen by the author in dairy cattle practice in West Wales together with references from the available literature.

Incidence and General Observations

Traumatic reticulitis has been the subject of several contributions to the world veterinary press. Most authors agree that the condition is the cause of the majority of primary gastric troubles in cattle (Imrie, 1927; Gotze, 1934; Noesen, 1938; Rorrison, 1945; Formston, 1949; Begg, 1950), though Gould (1949) and Davies (1950) gave the incidence as being very low. A recent statement by Maddy (1954) is rather interesting: "A frequent comment by veterinarians who, after years of large-animal practice have changed to meat inspection, is that had they known the actual high incidence of perforation of the reticulum by foreign bodies they would have handled many cases of bovine indigestion differently. After several thousand *post-mortem* examinations of dairy cattle carcases in routine meat inspection work, I came to the same conclusion."

Personal reflection satisfied the present writer that (a) many cases were wrongly diagnosed by him, in the past, as impaction or "indigestion," (b) primary ruminal impaction is an extremely rare condition in cattle.

Compared with other ailments, the incidence of traumatic reticulitis is not high as may be seen from the following figures:—

Nature of Ailment	*Number of Cases*		
	1952	1953	1954
Milk Fever	71	55	87
Red Water Fever	57	40	24
Acetonaemia	45	56	64
Dystokia	78	55	70
Mastitis	154	212	250
Pyelonephritis	12	24	55
Traumatic reticulitis	6	21	20

(January—April, 1955, 17 cases have been encountered).

Most cases were encountered during the winter months when cattle are housed usually from mid-November until April. Various types of foreign bodies were recovered; in 64 cases, 69 objects were found, comprising the following: 12 nails, two staples, six pieces metal, seven pieces fine wire, 38 pieces baling wire, 2 x 5 in. wire, one hair-pin and one safety-pin (open).

Multiple objects were recovered from a few cases, but no animal has been known by the author to be affected with traumatic reticulitis on more than one occasion.

All cases were encountered in adult cattle (including two bulls) except two in heifers.

The fact that cattle ingest foreign bodies more often than other species is correlated to their different method of prehension. Whilst sheep, goats and horses are selective feeders, cattle take food into the mouth by an outswept curling action of the tongue aided by backward pointing papillae on the latter, and very little mastication occurring at this time. Foreign bodies are thus more likely to be swallowed.

Phillipson (1946) stated that such objects, on being swallowed, fall in the recticulum. On reaching this organ they sink to the floor and are unlikely to be forced into the rumen because of the liquid nature of the recticular contents and the fact that when the reticulum contracts the reticulo-ruminal fold is drawn upwards and slightly medially, thus making the transference of such objects to the rumen difficult. (Personal observations.)

Schalk & Amadon (1928) in their studies of reticulo-ruminal motility in cattle, introduced nails *via* a ruminal fistula and placed them in the ventral ruminal sac. In a few days' time these objects were found in the recticulum.

It is widely believed that traumatic reticulitis occurs most frequently during late pregnancy or soon after calving, which is attributed to the increased intra-abdominal pressure causing obliteration of the reticulum. From the present survey, it was deduced that no such analogy exists—the large majority occurring about two to three months after calving and in 64 cases only six occurred within a month of parturition. Hansen (1953) reported similar findings.

The present author considers that the chief factors involved in causing penetration are contractions of the reticulum aided by movements of the diaphragm.

* A revised version of Part Two of the R.C.V.S. Fellowship thesis as presented to a meeting of the South Wales Division, B.V.A., at Saundersfoot on Friday, June 3rd, 1955.

The site of penetration of the reticular wall varied in the cases encountered. The ventral wall was found to be the most common site, *viz*:—

Site of Penetration	*Number of Cases*
Anterior reticular wall	19
Ventral ,, ,, ...	40
Posterior ,, ,, ...	5

These findings are in disagreement with those of Wright (1946) who referred to the anterior wall as being the most common site, sometimes the ventral wall but never the posterior wall. Phillipson (1946) attributed such findings to most movement occurring in the anterior wall. Hutyra, Marek & Manninger (1938) stated that the antero-ventral wall was the most common point of penetration which they considered to be due to contraction of the reticulum in the antero-dorsal direction, movements of diaphragm and abdominal pressure. They further stated that in breeding animals the posterior wall is more often injured because in coition the foreign body is pressed against this part of the stomach by the sudden increase in intra-abdominal pressure.

Careful examination of reticular contraction by internal palpation in the present survey revealed that the ventral wall was raised considerably during the second phase of reticular contraction by a sudden jerky movement; this factor lends support for present findings regarding the point of penetration.

Symptoms and Diagnosis

Even though various symptoms and methods of diagnosis have been described by several writers, a careful search of the available literature revealed that most authors found the condition very difficult to diagnose with certainty. Fairly recently, Churchill (1950) in an address to a group of American veterinarians, stated that he could not offer any new method of diagnosis, the latter depending on the correlation of a variety of symptoms. Thus a statement by Imrie (1927) still held good, *viz:* " none of the symptoms (excepting peritoneal tympany) is of signal significance when taken individually, but when linked together, form a chain of evidence strong enough to enable one to make a fairly accurate diagnosis, even when several of the links are absent."

In the majority of cases in the present series, sudden onset with a marked drop in milk yield in lactating animals was recorded (see Fig. 1), a feature described by most previous authors. Ingram (1950) reported a case of sudden death. Anorexia and cessation of rumination were found to be significant factors in the early stages without a history of a change of diet. This departure from normal health, however, was by no means constant. The average case revealed the animal standing with an arched back, anxious expression, head and neck outstretched and held low, elbows abducted slightly and with the hind limbs held more under the body than in the normal posture. Disinclination to lie down, with stiffness on exercise were usually evident. Most of these symptoms were also recorded by previous writers (Imrie, 1927; Hutyra, Manninger & Marek, 1938; Udall, 1943; Rorrison, 1945; Formston, 1949; Begg, 1950; Churchill, 1950; Merriman, 1954).

The veterinarian confronted with such a general clinical picture would probably associate it with some form of acute pain probably of abdominal origin; this would not necessarily mean a case of traumatic

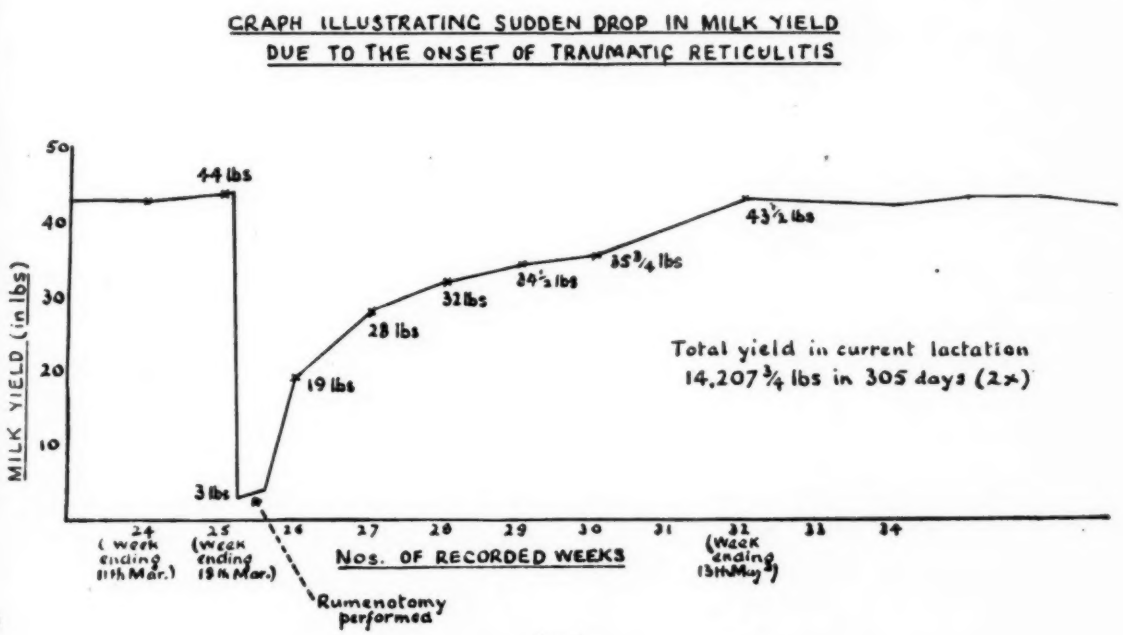

FIG. 1.

reticulitis because a similar appearance may occur in other ailments such as pyelonephritis, pericarditis, post-parturient metritis, non-traumatic peritonitis, endocarditis, etc.

The temperature recorded in most animals was remarkably constant even in very early cases, being closely in the region of 102.5° F. Very few cases showed a temperature of 104° F. or over, though Formston (1949) maintained that a temperature of 103° to 104° F. in the early stages was highly significant, falling to 102° to 102.5° F. in 24 to 48 hours in the absence of further complications.

Bowel movements have been described as being restricted or absent with the faeces coarse or undigested (Rorrison, 1945); dark and firm in consistency and passed in small quantities (Formston, 1949).

In the present author's experience, faeces were found to be normal for the prevailing diet in most instances, but defecation occurred often and in small amounts.

Respirations were more or less normal, whilst the pulse was slightly accelerated (65 to 80 per min.).

Ruminal stasis, especially in the early stages, has been quoted as being a feature of traumatic reticulitis (Imrie, 1927; Formston, 1949; Begg, 1950). From present knowledge of reticulo-ruminal motility and its part in the expulsion of ruminal gases, such cases would be expected to be accompanied by tympany. Such a correlation was not recorded by these authors. Tympany would not remain indefinitely because a certain amount of the gases might be absorbed through the ruminal wall whilst gas production also diminished rapidly if anorexia exists, with very little formed after a period of 24 hours (Washburn & Brody, cited by Cole, 1945).

Tympany was only encountered in the history to two cases in the present series, normal or retarded motility having been re-established before these animals were examined. It may be stated categorically that reticulo-ruminal motility was observed in all the positive cases encountered by the present writer. Motility was retarded in a considerable number and in such cases reticular sounds were difficult to interpret. This retarded movement accounted for the "doughty" nature of the dorsal ruminal sac in such cases on palpation at the left flank and is also the explanation for the so-called "peritonal tympany" observed by Arnold (1909) and regarded by Imrie (1927) as being a diagnostic feature. (This latter condition has been observed by the present writer in various abdominal ailments of cattle.)

Manifestation of pain in the form of a grunt seems to be a controversial factor and various authors described certain tests to reproduce or amplify the pain factor, such as:—

Percussion of the xiphisternal area by a percussion hammer (Formston, 1949) or by a pole held by an assistant on each side (Gotze, 1934).

Pinching of the withers.

Percussion at the ventral aspect of the left seventh rib (Noesen, 1938; Formston, 1949).

The production of a grunt in each case was considered of diagnostic value. All these tests have been carefully applied in the present survey. Most cases gave a positive result to one or all of these tests but a similar pain reaction was evinced when they were applied to many other diseased conditions, *e.g.*, endocarditis, pneumonia, pleurisy, generalised peritonitis, pericarditis, etc. These tests, therefore, cannot be accepted as being reliable, neither can Begg's (1950) contention that grunting during micturition is diagnostic. Further references to the pain factor were made by Hansen, New York State (1953) who referred to it as a typical "wire grunt" but without any further explanation; McGowan (1951) in Canada correlated grunting or groaning with each respiratory movement, whilst Rorrison (1945) found that a painful moan was emitted before ruminal movement. Gotze (1934) referred to sounds of a groaning or sighing nature sometimes coinciding with contraction of the reticulum. Lagerlof (1929) noted that in some cases, even in a weakened rhythm, one could frequently hear at the beginning of, and during, reticular contractions, the animal groaned once or several times.

The "Reticular Grunt" Method of Diagnosis

In view of knowledge obtained from a study of reticulo-ruminal motility in normal cattle, the correlation of the pain factor with reticular motility became the focus of close observation in this series. It will be recalled that ruminal movements were interpreted as being of two types:—

Primary contractions which coincide with reticular contraction, *no* eructation of gases taking place.

Extra-ruminal contractions, which occur independently of the reticulum, each accompanied by eructation of ruminal gases.

By observing the rhythm of motility at the left flank, the clinician can therefore distinguish, at a glance, between the two types of contractions simply by noting the contractions which are accompanied by eructation and those that are not.

Direct auscultation of reticular sounds may thus be dispensed with.

For the final diagnosis of a suspected case of traumatic reticulitis, the clinician must concentrate on observing the contractions of the rumen which are *not* associated with eructation, *i.e.*, the contractions related to reticular movement.

Since sharp pointed foreign bodies cause trouble by penetrating the reticular wall, it is a logical assumption that manifestation of pain in the form of a grunt should be related to the motility of this organ. By the combined method of examination (described in a previous paper) it was established that the primary ruminal movement reached its maximum contraction as the reticulum relaxed. In a positive case of traumatic reticulitis, one would expect a grunt to be heard about two to three seconds before the primary ruminal contraction could be palpated at the left flank, *i.e.*, during reticular contraction, and/or corresponding to this ruminal contraction.

This method of diagnosis has been applied by the author in every case of suspected traumatic reticulitis during the past three years and has been found by subsequent operation to be extremely reliable.

In the very large majority of animals, the " reticular grunt " was easily detected and a positive diagnosis was submitted without any hesitation (except in the first few cases, of course, when this method of diagnosis was being tested). In others, very careful observation over a considerable period of time had to be made (some cases were observed for up to 45 minutes!).

A striking feature in the series was that in a large majority, a grunt was only evinced during reticular relaxation, *i.e.*, when the dorsal ruminal sac reached its maximum primary contraction at the left flank. The following explanation is suggested: penetration of the reticular wall by a foreign object causes a localised area of inflammation at this point. This involves the serous covering of the reticulum and adjacent structures (principally the diaphragm and ventral abdominal wall). Generalised peritonitis is only rarely encountered as the result of such penetration, probably due to the remarkable resistance of the bovine peritoneum to infection as compared with other animals. Pressure on this localised inflammatory area would naturally cause pain, manifested in the form of a grunt. When the reticulum relaxes, stomach ingesta flow back into it, the flow being aided by the contraction of the dorsal rumen. This refilling and distension of the reticulum causes sudden increased pressure on the structures adjacent to its outer wall. In a positive case, therefore, this act would cause pain and hence a grunt.

A common feature of general practice is that many diseased conditions are often not encountered in their initial stages. It happens sometimes that animals will have shown signs of illness for a few days before the veterinarian is consulted. When presented with a suspected case of "foreign body," such information must be carefully acquired. A few of the cases encountered in this series were confronted likewise and presented rather difficult problems. Most of these showed a variable appetite, occasional rumination, only slight arching of the back and more or less normal faeces. Very careful application of the " reticular grunt " syndrome, however, solved these cases, though the grunting was very faint and did not occur with every reticular movement. In some cases, the grunt took the form of " a muffled inspiratory sound " and was only detected by keen observation. A noteworthy factor in many cases was that the pain factor was also accompanied by the exhibition of general discomfort in the form of alternate movement of the fore limbs. (It is interesting to note that Lagerlof (1929) reported having seen cases where " contraction of the reticulum caused such severe pain that, on each occasion, the animal lifted its back which was already arched and, so to say, shrunk together from the pangs, at the same time groaning or kicking one of its hind legs against the abdomen.")

In order to reproduce or amplify the pain factor, either of the following tests are suggested:—

Taking the animal outdoors for a brisk walk, preferably downhill.

Inducing the patient to eat some hay followed by a couple of bucketfuls of water to increase motility and hence amplify the grunt (if the animal will co-operate!).

Careful observation of the patient immediately afterwards should solve such cases.

Other Diagnostic Methods

(a) *The cintel metal detector* has been used as an aid to diagnosis. Formston (1949) cited this instrument as doing nothing more than confirming the presence or absence of metallic objects in the reticulum, the diagnosis of reticulitis being based on clinical findings. The same author warned that it is possible for free metallic objects to be demonstrated and removed, which are not actually responsible for the symptoms exhibited, and observed that cattle grazing on pasture recently dressed with " basic slag " gave a pronounced reaction to the detector. Begg (1950) referred to its value as being strictly limited.

The present writer does not possess this instrument and is, therefore, not qualified to assess its diagnostic value. However, it is understood that, owing to the nature of the soil in certain parts of south-west Wales, a positive reaction may be expected in normal animals.

(b) *Haematological Examination.* Blood samples were collected from 15 confirmed cases of traumatic reticulitis in the present survey. Whilst all samples showed a fairly constant blood picture, such examination cannot be defined as being diagnostic in view of similar findings in other ailments. A similar blood picture was found by Evans (private communication, 1955) in a confirmed case of traumatic pericarditis and by Marr & Jarrett (1955) in a case of displacement of the abomasum associated with peptic ulceration.

Differential Diagnosis

Certain stages in the clinical manifestation of several diseased conditions may be confused with that of traumatic reticulitis, such as the following:—

Ruminal Impaction—debatable whether this condition exists; Acetonaemia; Post-parturient metritis;; Pyelonephritis; Diffuse non-traumatic peritonitis; Traumatic pericarditis; Endocarditis; Pleurisy; Broncho-pneumonia; Intestinal obstruction; Displacement of the abomasum (Begg in a private communication considers this a common ailment); Initial stages of some cases of Johne's disease.

The author is satisfied that the differential diagnosis should be based on the identification of the " reticular grunts."

Prognosis

The close proximity of the reticulum to other vital organs, such as the heart, must be borne in mind when considering the prognosis of traumatic reticulitis. Each case must be dealt with on its merits and much depends on the stage at which professional advice is first requested.

If surgical removal of the offending object is carried out, a good prognosis may be submitted provided such measures are adopted in the early stages. On the other hand, whilst it is admitted that several cases probably recover on their own accord without surgical intervention, the possible complications have to be pointed out to the owner.

Treatment

A considerable divergence of opinion exists in this sphere. Hutyra, Marek & Manninger (1938) referred to Obich having recommended operative removal of foreign bodies with the patient standing, in 1863.

A similar operation was quoted by the same authors as having been described by Wenger (1910), but the results obtained were unsatisfactory, apparently due to the selection of patients in which the disease was too far advanced. Reference was also made to Kolb (1892) who reported the effect of the elevation of the forequarters by means of a slanting platform. This latter method was adopted by Imrie (1929) and recommended by Davies (1950). Initial starvation and administration of mild purgatives with operation in five to six days if there was no recovery was advocated by Rorrison (1945).

Muller (1952) treated 43 cases with novalgin and penicillin and placed them on boards. Of these: seven were slaughtered within eight days, two in late pregnancy, two for other reasons, while 32 remained free from symptoms for three years.

Initial medical treatment was strongly recommended by Merriman (1953) who considered that " in our zeal for surgery and for new diagnostic techniques, we must not neglect the rôle that proper medication may play in a suspected case of traumatic reticulitis."

On the other hand, immediate resort to surgical removal of the offending object, as being the only rational approach, has been strongly advised by Noesen (1938), Formston (1949), and Begg (1950).

In the author's experience, since the adoption of the " reticular grunt " method of diagnosis, surgical intervention has been resorted to in all the cases with 100 per cent. recovery (except for one fistula).

On some occasions, surgical measures were unavoidably delayed until the following day. In these cases, though typical symptoms were shown on the first day of examination, and no medical treatment given, remarkable improvement had occurred when next visited especially if the animal had been starved in the meantime. The " reticular grunts " were not heard so distinctly and to the casual observer the animal seemed almost normal. Administration of food or water in these cases normally reproduced the grunts and subsequent operation revealed the offending object.

This apparent improvement in health undoubtedly accounts for so many cases of " foreign body " not being recognised as such, with such recovery being falsely attributed to the medical or " board " treatment which might have been adopted.

It is admitted that many positive cases probably recover on their own accord, but it is impossible to forecast such a result. In view of the possible complications, the writer emphatically considers the surgical removal of the offending objects to be the only logical approach for traumatic reticulitis, provided the ailment is encountered in its fairly early stages.

Foreign bodies may be removed from the reticulum by rumenotomy which is performed at the left flank. Since this operation and methods of anaesthesia are well known, a detailed description is not considered necessary.

Conclusions

Reference to the available literature failed to reveal a reliable diagnostic method for traumatic reticulitis. As the result of very careful application and observation of the " reticular grunt syndrome " in 64 suspected cases with subsequent confirmation by surgical measures, this method of diagnosis is suggested as being reliable.

The syndrome is based on the correlation of the manifestation of pain in the form of a grunt (of variable intensity) with the motility of the reticulum. interpreted by observing ruminal movements at the left flank.

When presented with a suspected case of " foreign body," the following routine should be adopted. Having carried out the preliminary examination, the rhythm of ruminal motility should be noted (by observing the left flank). Attention should then be focused on the ruminal contractions which are *not* accompanied by eructation. In a positive case, a grunt should be heard two to three seconds before, or during these contractions. It should be emphasised that sometimes a prolonged examination involving taking the animal outdoors for brisk exercise or inducing the patient to partake food or water, to increase reticulo-ruminal motility and thereby amplify the grunt, has to be resorted to before a positive diagnosis may be submitted.

It is now known that this method of diagnosing traumatic reticulitis is not entirely original in its conception for Lagerlof (1929) demonstrated the value of auscultating reticular sounds in such conditions, but the same author made no reference to the correlation of reticular contractions with the ruminal movements which are not associated with eructation. (The present writer was unaware of Lagerlof's work when the original thesis was written.)

It is hoped that the results in the present survey will be corroborated by future cases and by other clinicians. If so, traumatic reticulitis may be cited as one diseased condition at least, in which the unfortunate patient can reveal where it feels pain, provided we know enough about its normal physiology and can exercise the patience to locate such pain.

Summary

1. A new method of diagnosing traumatic reticulitis is submitted.

2. This method is based on the correlation of pain, manifested in the form of a grunt, with reticular movement.

3. Reticular motility may be interpreted by noting the ruminal movements which are *not* associated with eructation of ruminal gases.

4. In positive cases, a grunt should be heard two to three seconds before, or when, the primary ruminal movement reaches its maximum contraction, as observed at the left flank.

5. This diagnostic method was found to be completely reliable in 64 cases.

6. In the majority of cases penetration of the reticulum occurred through the ventral wall.

7. Pieces of baling wire were chiefly encountered as the offending objects.

8. It is suggested that medical and "board" treatments are of little value and could be misleading.

9. Surgical removal by rumenotomy is considered the only logical approach in diagnosed cases, in view of possible complications which might otherwise occur.

10. Haematological examinations of 15 cases revealed a leucocytosis with a "shift to the left." Such tests, however, cannot be considered diagnostic for traumatic reticulitis.

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The Diagnosis of Some Obscure Lamenesses in the Horse and An Improved Technique for Acid Firing*

BY

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Ashford

AT times the diagnosis of lameness in the horse is a headache for all of us, but in particular for the more recent graduates and those members of the profession whose practices are mainly concerned with the treatment of other animals. Those of us whose life has been spent amongst horses have a great advantage in this respect because a knowledge of the horse in normal health is essential before one can begin to diagnose illness and unsoundness. I therefore hope that you will forgive me if, in the course of my remarks, I mention details which are well known to the more experienced horse practitioners, but may be of use to others. I do not propose going into great detail or dealing with a large variety of conditions but will attempt to give you some important points as aids to the diagnosis of certain lamenesses in the fore and hind limbs with emphasis on the varying gaits in the hope that a good discussion will result.

It is a great help in diagnosis to have clearly fixed in one's mind a few salient points typical of each variety of lameness.

How often something like this occurs: you are shown a lame horse but careful manual and visual examination fails to reveal any cause for the lameness. You tell the owner to rest the animal for a few days but still the horse is lame. This may occur several times and still no local symptoms appear. You then probably block the plantar nerves but the horse remains lame.

In such a case I contend that you should make a diagnosis from the gait of the horse when you have waited a reasonable time to allow local symtoms to develop. If you delay, the owner will lose all faith in you and will probably obtain the opinion of some horsey friend who, in fear lest he lose his reputation as "knowledgeable about horses," will make a guess as to the seat of lameness. This, of course, is quackery. The veterinary surgeon, on the other hand, by applying his professional knowledge and experience of known peculiarities of the various lamenesses, should have arrived at a diagnosis which, even if incorrect, was at least deduced on a scientific basis.

Remember that the more obscure the lameness the safer you are in giving a definite opinion because it is all the more difficult to prove that you are wrong!

Shoulder.—Irrespective of whether the seat of injury or disease is the joint, bone or muscle, shoulder lameness presents certain definite characteristics. Firstly, the horse has difficulty in taking the leg forwards and at each stride with the affected leg, marked

* Paper delivered to the Midland Counties Veterinary Association on May 11th, 1955.

raising of the head occurs. Secondly, a short stride is taken with the lame leg in order to avoid moving the painful shoulder. The symptoms of pain are in evidence when the foot is in the air. In other words, swinging leg lameness. (As a student I remember being puzzled when told that a horse took a shorter stride with one leg than with the other as I failed to understand how the leg taking the shorter stride kept up with its fellow.)

Other points to note are a tendency to stumble, caused by inability to lift the foot clear of the ground. A very different stumble to that seen in foot lameness such as navicular disease where the stumble occurs at the end of a completed stride when the foot is being placed on the ground. Two simple tests can be tried in suspected shoulder lameness: trot the horse up a slope or in soft going; in both cases the lameness is intensified whereas in foot lameness it is lessened. In short, the pain causing the lameness is only active when the limb is carried and not when the weight of the body is placed on it. Remembering this one fact is of the greatest help.

Knee Lameness.—Carpitis is probably a more common cause of lameness than is supposed. External injuries to the knee and rheumatism are mentioned as the most likely causes.

The most diagnostic feature in this type of lameness is the circular sweep of the limb when moved forwards. The horse, in his endeavour to take a stride with as little flexion of the painful knee joint as possible, abducts the limb. The quarter or heel is brought to the ground first and the animal may stumble. The lameness is intensified down hill and objection is shown to forcible flexion of the joint. This condition is quite a common cause of chase horses refusing or jumping sideways. It has been called "knee spavin" and coarse bred horses and horses with small knees and upright shoulders are more prone to develop it. In many cases it is incurable but I have known horses to continue to work even with the flexion of the joint considerably reduced.

Splint Lameness.—Resembles the foregoing in many ways, the limb being abducted and the lameness being worse down hill. The lameness is more marked on hard than soft ground and increases with exercise. In addition, the horse may walk practically sound but trot decidedly lame.

Sore Shins.—I am including this condition in the hope of obtaining some advice. During the last few years I have had a number of cases in old horses; that is to say, in horses over six years of age. All were in training as chasers or point-to-point horses and the symptoms shown were loss of action in both fore limbs resulting in a pottery gait; in fact, "lame both fore." In addition, there was great tenderness on palpation of the shins but no swelling or heat. In some horses it was so pronounced that the animal would almost fall down when the shin was pressed upon. After rest and in some cases application of liquid blister most horses recovered and were put back in training, but in some the condition kept recurring.

To state that sore shins is an osteoperiostitis of the cannon bone may be correct in young immature horses when heat and swelling are present, but it is difficult to see how this can apply in old horses not showing these symptoms. One would suspect the extensor tendons or their sheaths as a possible seat of the trouble, but there again there were no local symptoms to support this assumption.

I wondered if it could be due to an irritation set up in the nerve endings between the skin and underlying tissues; to some extent I had confirmation of this as one horse running under Jockey Club rules was very pottery. I had Xylotox paste rubbed into his shins 30 minutes before a race and he walked out sound and ran second.

Thorns.—In dealing with mysterious lameness in hunters do not forget the possibility of the cause being a thorn imbedded in the tissues; the thorn may have completely disappeared under the skin leaving no external evidence of its presence. One would expect suppuration to occur in a few days' time and an abscess to form at the point of entry, but this does not always occur. The most common places where the entry of a thorn will cause lameness are the knee, fetlock and coronet.

You may be interested to hear of two such cases:—

1. A hunter with an obvious injury to the front of the knee which was swollen and tender; the owner and veterinary surgeon examined carefully for a thorn without success and after treating the case for 14 days with fomentations and antiphlogistine sent the animal to a well-known diagnostic establishment where the knee was X-rayed and, finding nothing, treated with the electric pad. The animal was returned home in a fortnight with a diagnosis of injury to the structures in front of the knee joint; some days later the owner noticed a small bleb on the knee and extracted a blackthorn about an inch in length.

2. A well-known three-day-event horse went slightly lame after a hunt in the Midlands with heat and pain round the coronet; again a thorn was suspected but could not be found and the horse became almost sound after the usual treatment but again went lame when hunted. This went on for over a month when at last the veterinary surgeon, with some courage, cut a window in the hoof just below the tender spot on the coronet and succeeded in finding a very long thorn imbedded between the sensitive and horny laminae at least an inch below the coronet.

If you suspect a thorn, shave the suspected site and even use a magnifying glass.

Foot Lamenesses.—The number of diseases and injuries of the foot which may cause lameness are legion. I only propose dealing with two or three which are really the only ones to come under the heading of this paper.

As we all know, the commonest seat of lameness in the fore limb of the horse is the foot and I would even go so far as to say that the veterinary surgeon who diagnosed every case of foreleg lameness, where no local symptoms were in evidence, as in the foot, would seldom be wrong.

When I am told by a client that a horse is suffering from shoulder lameness I at once suspect the foot and with the aid of plantar block have confirmed it many times.

In passing, I might mention a simple aid to the injection of a local anaesthetic over the plantar nerves. I always inject the anaesthetic with the foot held up, because then there is less danger of the needle penetrating the nerve, artery or vein as they are not taut. Very often the horse will flinch as the needle goes in and jerk the needle out of one's hand, probably into the bedding, where it is unlikely to be found. To prevent this I tie round the limb just above the fetlock, over the site of injection, a narrow piece of rubber, the needle is first inserted through the rubber and then pushed into the skin; if the horse snatches his foot from the man holding it, the needle is still held by the rubber.

I suppose one of the soundest rules of veterinary practice is to search the foot in all cases of lameness but the fact that you cannot find anything by such an examination does not mean that the lameness is not there. Indeed, in most cases of navicular disease and pedal ostitis no pain is evidenced by the horse on tapping the foot or compressing it with hoof testers; likewise no heat can be detected.

Navicular Disease.—The typical symptoms of this disease are well known to you all. The most important points to remember as aids to diagnosis are:—

Both forefeet are usually affected and very seldom the hind feet. The onset of lameness is, as a rule, insidious and intermittent and one or both feet may be pointed in the stable. Lameness is more marked the day after work and gradually improves with exercise. The horse takes short strides and digs his toes into the ground, giving the impression that he is tied in at the shoulder, and often stumbles when the toe strikes the ground. The patient adopts this short stilted action in his efforts to relieve as quickly as possible the pain caused by the foot bearing weight. It is supporting-leg lameness, the pain being greatest when the foot is on the ground bearing weight. When turning he screws round, pivoting on his forefeet in an endeavour to carry out the manoeuvre without lifting his feet off the ground.

If I suspect this disease I proceed as follows: if the lameness seems to be in one foot only I block the plantar nerves in that leg and in most cases the horse goes lame in the other leg thus proving that he is lame in both fore. This in itself is a good indication that you are dealing with a case of navicular. Next, if the owner agrees, I have the feet X-rayed and in this connection I would like to give you my experience. It is practically useless to X-ray a horse's feet with a low-power set. In order to get a good picture a short exposure with a high-power set is essential; even the slightest movement, often imperceptible to the onlooker, spoils the picture and makes its interpretation impossible. Secondly, only an expert with long experience can detect navicular disease, at any rate in the early stages, from an X-ray film.

I believe that many operators do not carry out the procedure in the best way. As you know, the first really effective technique for the X-raying of horses' feet was evolved by Prior, and later by Oxspring, at the R.A.V.C. Laboratory at Aldershot. They considered that it was essential to plug the frog with horn filings, after removal of the shoe, and to fix the foot in the special stand which they invented, in order to get the tube directed through the hoof at the exact spot necessary. It is most annoying to send a horse for X-ray and get back blurred films and no definite answer from the experts.

Pedal Ostitis.—The lameness in this condition is similar in many ways to that of navicular disease but it occurs more often in one foot. The lameness comes on gradually and is intermittent and disappears with rest. There may be local heat and evidence of pain on percussion and compression of various parts of the foot depending on the structures involved. At first the bone becomes more rarified but later gets denser. Small excrescences develop on its surface and penetrate the sensitive tissues causing the pain and lameness.

Any part of the os pedis may be involved; not only the solar surface. A common site is the wing of the os pedis, where bony deposits occur and from there the process of ossification may involve the lateral cartilages forming sidebone. Another common site for the formation of the osseous excrescences is beneath the heels, where they cause compression of the soft tissues between the horn and the bone giving rise to staining of the horn, *i.e.*, corns; indeed, I have come to believe that nearly every case of corn is really a symptom of pedal ostitis. This disease is incurable but with careful shoeing and judicious use it is often possible to keep the horse in work.

Side-bone.—This is not supposed to be common in riding horses but I think there are many undetected cases where only that part of the lateral cartilage which is hidden by the hoof is affected. Such cases are probably caused by an ostitis spreading from the wings of the os pedis. I had a case such as this some time ago. The horse, a very big hunter, had been going lame on and off in the off forefeet for some time. On plantar block in that leg he went lame in the other. He had very high boxy feet and I diagnosed navicular disease and advised putting him down, but in order to satisfy the owner, who was very fond of the horse, we sent him to the Animal Health Trust for verification of diagnosis. An extract from the report by Professor Miller is as follows:—

Post-Mortem *Examination of Both Forefeet of a Bay Gelding*

The feet of this horse were examined after removal. X-ray examination showed four well-formed and fairly extensive side-bones affecting the cartilages of both forefeet. On the inner aspects of these side-bones there was a certain amount of active exostosis shown in the near forefoot particularly well, but clearly distinguishable in both. The exostosis had affected the second phalanx, os corona, and spreading on to the coffin joint. It was impossible to be quite certain whether there was navicular disease present or not from the X-ray examinations. Had the horse been living at the time the examinations were made, there would not have been the same difficulty but after death a certain amount of condensation of tissue takes place and the X-ray pictures are more difficult to take than when living.

On boiling the feet out afterwards, the extent of the side-bones was confirmed and it became clear that the exostosis was perhaps more serious than

we had thought. It had just begun to impinge on the ends of the navicular bone and I feel certain that some of the pain causing the lameness had been due to this impingement. There is no doubt that the condition would have got worse, possibly rapidly, and the end would have been a complete ankylosis of the whole joint. The navicular bones when boiled out show a considerable area of roughening on the surface over which the deep flexor tendon plays. The tendon itself was a little excoriated and chronically inflamed. There is, however, no actual erosion of the bone substance to be seen though it is quite probable that this would have been the next stage in the development, if the horse had lived.

These findings indicate quite clearly that the horse would undoubtedly have been a cripple for the rest of his life and that as the bony enlargements increased in size they must have caused a considerable degree of pain.

Hind Leg Lameness

Hip Lameness may be due to various causes such as disease or injury of the joint, or sprain of one or more of the various muscles in this area. The type of lameness varies somewhat according to the part affected, but its general characteristics are similar. The horse shows difficulty in taking the leg forwards (swinging-leg lameness), and the stride is shortened. In many cases there is a tendency to stiffen the leg and drag the toe. When the hip joint is affected there is supporting leg lameness and the animal tries to avoid throwing weight on the affected leg. This is not shown when muscles are affected. Lameness is more marked on backing and turning, and when trotted the horse often goes sideways; the affected quarter being raised.

In contrast to this a horse lame in the stifle shows more or less severe lameness at the walk and when trotted may carry the leg holding it flexed; also, when standing still he frequently lifts the limb and holds it forwards flexing the stifle joint. A hip case never does this. During progression the quarter on the affected side is lowered at each step.

During the past few years I have seen quite a large number of cases of stifle lameness in young stock as an after-effect of temporary dislocation of the patella. I have noticed that the majority were in overgrown yearlings or two-year-olds, presumably due to the ligaments being slack.

Spavin Lameness is characterised by the horse taking a short stride with the affected leg, the hock is not flexed normally and as a result the toe of the shoe is frequently worn by touching the ground. The lameness improves with exercise and the quarter of the affected leg is lowered at each step. Turning the horse in a small circle with the lame leg outside increases the lameness and the animal has a jerky spasmodic way of taking the foot off the ground probably due to the increased pain when the joint is extended. Forced flexion of the affected joint increases the lameness in many cases, but not in every case.

Ricked or Jinked Back, for which the French have a much better name—*Immobilité*—may be due, I believe, to several causes. Firstly, ankylosis of the vertebrae following some injury such as a bad fall; secondly, injury to the muscles of the back resulting in the formation of fibrous tissue and even calcification, thereby interfering with their normal function; and, lastly, injury to the spinal cord. Whatever the cause and pathology of the condition it is a serious unsoundness, as in most cases it is incurable, and one has to depend entirely on the peculiar gait of the horse in its diagnosis.

There is weakness of the hind quarters and the horse often shows a swaying motion, from side to side, when trotted in a straight line, and on turning appears to lack co-ordination, using the hind legs in an awkward manner, throwing the outside leg outwards as if unable to pivot on it. If turned quickly a bad case may even fall down. The horse objects to backing and often does not lie down at night.

I always ride suspected cases because they give one a dead sort of feel and, when pulled up out of a trot, stop in a jerky way, being unable to get the hind legs under the body to act as a brake. In some cases the hind legs intercross at the trot and may strike each other. The quarters may wobble to such an extent that on entering or leaving the stable they may strike the side of the door.

Shivering.—This is mostly seen in draught horses but does occur in riding horses and in some ways resembles the foregoing. We know little about the cause of the complaint, which is said to be a neuro-muscular disease, but I feel that some cases are caused by injury to the back.

The classical symptoms are that on lifting a hind foot or on backing the horse, the limb is suddenly raised, semi-flexed and abducted, shaking or shivering in suspension; the superficial muscles of the thigh and quarter quivering with the tail elevated and tremulous. A great variation of symptoms are to be seen even in the same case and diagnosis is often very difficult on a single examination.

Some cases show the symptoms if moved over in the box, others when being shod. A horse suffering from the complaint will sometimes show it when led into a straw bed or on to a wooden floor. (As regards the straw, one needs to be careful because some thin-skinned horses will snatch up their hind legs due to the irritation of the straw at the heels.)

Most shiverers do not lie down and consequently lose condition. The disease is said to occur in the fore limbs but I have never encountered it there.

Professor Wright once said: "The more I see of lameness the less obvious the cause becomes." These words, I think, put in a nutshell the experience of most of us; one passes through a sort of professional metamorphosis; starting with the undeveloped student's theoretical stage, gradually merging into a period of dogmatic, fixed ideas, which as experience is gained become shaken and exploded until at last one comes to realise how little we really know about this important subject.

A Technique for the Acid Firing of Horses

This method of inducing counter-irritation in the treatment of sprained tendons and other conditions in horses is one of the oldest methods known and has been practised by the Arabs for centuries and still is, although in a very crude way. I never used

it during my time in the Army because I had seen some cases treated in this way in which unsightly scars had resulted, caused by the difficulty of controlling the acid so that it spread and ran down the leg.

Mr. Walker, of Slough, introduced this method of firing to Kent many years ago and after numerous requests from clients I eventually tried it, with some misgivings. The results were so successful and the advantages so great as compared with the hot iron that now I employ no other form of firing for sprained tendons or indeed for several other conditions.

In order to control the acid and prevent it running down the leg and spreading beyond the actual point of application I use the following technique: A roll of "Sleek," which is a type of very thin adhesive plaster 4 inches in width, is prepared by punching holes in it $\frac{3}{8}$ inch in diameter and $\frac{3}{4}$ inch apart or if smaller firing marks are required, $\frac{1}{4}$ inch holes, $\frac{5}{8}$ inch apart. The distance is measured from centre to centre. With a 4-inch roll it is possible to get five vertical rows of holes, one down the centre and two at either side, the holes being staggered. In most cases I use the larger holes.

The leg to be fired is prepared by removing the hair, preferably the day before the operation, by means of a depilatory paste (barium sulphide), and then washing it well and drying thoroughly. A piece of the prepared Sleek is then stuck round the leg with the centre row of holes down the back of the tendon. The length of the piece of Sleek should be such that it projects below the fetlock so that any acid running down will fall clear of the leg. About 10 to 12 inches is the length required.

Concentrated sulphuric acid is then applied through the holes by means of a cork, of a size to fit the holes exactly, fixed on the end of a handle. Any surplus acid which runs down the leg goes over the Sleek and can be wiped off with a piece of cotton wool. Some experience is required to estimate how much acid to apply. The amount varies with the texture of the skin; I usually touch each spot twice. The Sleek can be removed in 10 minutes. The result is a series of neat firing marks down the back and sides of the tendons resembling those made by a budding iron.

FIG. 1.—Showing sleek stuck on leg preparatory to firing.

At first the skin becomes raised slightly into a circular plaque at each firing point, later these plaques become hard and eventually the central portion of skin dies and a very small piece becomes detached leaving a small scar. A few days after firing I have an antiseptic ointment applied (propamidine cream).

Advantages of Acid Firing.—1. No anaesthetic is required and most horses stand without a twitch with the opposite foreleg held up. Apparently the acid has the effect of paralysing the superficial nerves in the skin and only a slight stinging sensation is felt by the horse on the first application. With the second I do not think they feel anything.

2. There is no subsequent pain and very little swelling.

3. The contraction of the skin is at least as great as with the hot iron and the fired tendons become firm and hard.

4. As there is no after pain it makes the firing of the sound leg unnecessary.

To date I have fired 25 horses with acid—21 sprained tendons, three sprained ligaments fetlock and one spavin; of these, three were chase horses, 10 point-to-point horses and the remainder hunters.

With two exceptions all the tendon cases have continued to race or hunt and remained sound.

The severity of sprain has, of course, varied considerably but some were really bad sprains affecting both flexor tendons. Three horses in particular have tendons as thick as one's wrist. Of the three chasers, one has won two races this season and been placed on another occasion. Another with two enormous tendons has run five times, been placed once, fallen twice, and won his last race in a canter.

As in all forms of treatment of sprained tendon, the after-treatment is of the greatest importance. It is a mistake to turn horses that have been fired out to grass too soon and I insist on them being kept in a straw yard, barn or small paddock where there is not sufficient room to gallop until I am satisfied that the injury to the tendon has been repaired.

This form of firing has a great appeal to those people who do not wish to subject their horses to the pain and discomfort of the actual cautery.

Equipment.—1. Sulphuric acid, concentrated, in a shallow dish; only about $\frac{1}{4}$ inch of the bottom being covered with acid.

2. A cork of the required size with a piece of wire stuck in it to act as a handle.

3. Rubber gloves.

4. Sleek.

5. Cotton wool.

6. A bucket of water to wash off acid accidentally spilled on hands, etc.

FIG. 2.—BF legs (Chaser) fired on 18/8/52 for sprain of superficial and deep flexor tendons.. Has since run in many races, won once and placed several times.

FIG. 3.—NF leg (Point-to-Pointer) fired on 16/6/55 for sprain of superficial and deep flexor tendons.

The punching of the holes in the Sleek took longer than the firing operation until I provided a piece of board measuring 5 x 18 x ½ inch covered with linoleum; a second board measuring 6 x 18 x ¼ inch with holes drilled in it at the required intervals and of a size to admit a punch. This board has two pieces of wood fixed on each side measuring 18 x 1 x 1 inch so that when placed over the linoleum covered board on a table, there is a space of approximately ½ inch between the two boards.

The Sleek is fixed to the linoleum with three drawing-pins at each end. The sticky side is uppermost and the pattern board placed over it. Holes are punched in the Sleek by inserting the punch through the holes in the board and giving it two or three smart blows with a hammer and withdrawing the the punch with a jerk. The Sleek is then rolled back on to a cylinder of some kind and is then ready for use; I use old tooth-brush tubes. In this way sufficient Sleek for two legs can be prepared in about five minutes.

Victoria Veterinary Benevolent Fund

A MEETING of the Council of the Victoria Veterinary Benevolent Fund was held at 10, Red Lion Square, on October 14th, when the following members were present:—

Mr. H. W. Dawes (President) in the chair, Mr. E. P. Barrett, Professor T. J. Bosworth, Major J. J. Dunlop, Mrs. D. I. Glover, Professors R. Lovell and J. McCunn, Captain T. M. Mitchell, Professor P. E. Mullaney, Mrs. F. M. Ritchie, Mr. J. N. Ritchie, Major H. Sumner, Captain Wm. Watt and Professor W. L. Weipers.

Mr. C. W. Francis, Secretary, was in attendance.

1. *Welcome to new President of the Ladies' Guild.*—Before commencing the business on the Agenda, the President extended a cordial welcome to Mrs. F. M. Ritchie, the newly elected President of the Ladies' Guild.

2. *Minutes.*—The Minutes of the previous meeting held on June 28th, 1955, having been published in THE VETERINARY RECORD, were taken as read and signed as correct.

3. *Apologies for Absence.*—The following members had expressed regret at being unable to attend: Mr. G. N. Gould, Captain W. R. McKinna, Mr. G. P. Male, Dr. R. F. Montgomerie, Professors C. W.

Atomic Warfare and the Profession

(*Continued from page 921*)

healthy livestock. Plans must be simple so that they would work in the utter confusion which would reign in these conditions, and thought must be given to arrangements for effective liaison and assistance between the profession, the Civil Defence Corps and the Ministry of Agriculture, Fisheries and Food which now has the double responsibility of food production and distribution.

The profession will not be adequately prepared to fulfil its war-time function unless some instruction and training is given in peace-time. It is known that the Ministry has already given special training to a number of its veterinary research staff, but so far, most veterinary surgeons in private practice have had little opportunity to study the technical aspects of the effects of radiation on animals. Fortunately, the security difficulties of making information available are now much less formidable than they were a few months ago.

The rôle of veterinary surgeons in war-time is under discussion between the Government and representatives of the profession, and consideration is being given to means for informing veterinary surgeons, as well as veterinary students, about the effects of radioactivity on animals. The last few years have seen a rapid development in the use of radioactive techniques in scientific research, and particularly in biological research. Few would care to prophesy on the extent and nature of the use of atomic energy in research, or even in practice, in 10 years' time. Quite apart from any civil defence value, a knowledge of radiobiology seems to be rapidly becoming an essential item in the training of future veterinary surgeons.

Ottaway and L. P. Pugh, Major C. W. Townsend, Captain A. Whicher, Professor G. H. Wooldridge and Major W. H. Wortley.

4. *Correspondence.*—(a) A letter was read from the Hon. Treasurer of the Ladies' Guild informing the Council that at the Guild's recent Annual General Meeting at Belfast, it was decided to donate to the Fund £350 for the current relief account and £600 to the special gift account. The Council were deeply moved by this splendid news and the Secretary was directed to convey to the members of the Ladies' Guild, through Mrs. D. I. Glover, their Hon. Treasurer, the Council's very sincere gratitude for these generous contributions to the Fund.

(b) The Secretary reported the receipt of a letter from the Veterinary Medical Association of Ireland enclosing cheque for the sum of £239 12s. 6d., made up of 10 guineas from a member for Life Membership, subscriptions collected for 1954, the proceeds of a Dance and Gymkhana and the refund of tax in connection with the Greyhound Charity Meeting held last year.

The Council was greatly impressed by this handsome contribution and directed the Secretary to place on record its appreciation and thanks for the valuable help rendered to the Fund by the Veterinary Medical Association of Ireland.

(c) The Secretary reported that he had received a letter from Mr. J. C. Wallace, Chief Superintending Veterinary Officer, Ministry of Agriculture, enclosing cheque for £86 which had been subscribed by colleagues and friends of the late Mr. W. Rhodes, formerly Divisional Veterinary Officer, as a tribute to his memory.

It was resolved that the Secretary be requested to write to Mr. J. C. Wallace, expressing the sincere thanks of the Council to all concerned for kindly donating this generous sum to the Fund, which will be used for current relief, as suggested.

5. *Treasurer's Report.*—The Treasurer reported the following transactions which had taken place since the previous meeting:—

(a) *General Fund.* That the legacy of £1,000, less bankers' charges, left to the Fund by the late Mr. Peter Conacher, M.R.C.V.S., South Africa, particulars of which were reported to an earlier meeting, was duly received on July 15th, and following a consultation with the other members of the Executive Committee, the amount had been invested in the purchase of £1,272 17s. 2d. 3½ per cent. War Loan.

(b) *Wortley Axe Fund.* That the accumulated balance in this account, as shown in the last Annual Report, amounting to £321 0s. 3d. had been invested in the purchase of £358 11s. 3d. 2½ per cent. Funding Stock, 1956/61.

It was resolved that the action of the Treasurer be approved.

6. *Accountant's Report.*—The following report was read and approved and the Secretary was instructed to express the thanks of the Council to the respective donors:—

Since the previous meeting of Council the following legacy, special subscriptions and donations have been received:—

LEGACY

	£	s.	d.
P. Conacher, M.R.C.V.S., South Africa. £1,000 (less bank charges)	996	4	3

DONATIONS

	£	s.	d.	£	s.	d.
Life Membership, R. R. Pierse, Eire	10	10	0			

COLLECTING BOXES

East Midlands Division	2	17	6			
Scottish Metropolitan Division ...	2	0	0			
British Timken Show	1	1	0			
Elstead Horse Show	1	1	0			
Lincs. and District Division	5	0	0			
Windsor Championship Show	5	5	0			
				27	14	6

SUBSCRIPTIONS

	£	s.	d.	£	s.	d.	£	s.	d.
Herts. and Beds. Division				7	2	0			
Veterinary Medical Association of Ireland:									
Members' subscriptions ...	78	6	6						
Dance	95	16	2						
Refund of Income Tax on greyhound benefit meeting	54	19	10						
				229	2	6			
V.V.B.F. Ladies' Guild				350	0	0			
"In Memory of Wilfred Rhodes" (subscribed by friends and colleagues)				86	0	0			
							672	4	6
							£1,696	3	3

7. *Life Member.*—It was resolved that Mr. R. R. Pierse, M.R.C.V.S., be elected a Life Member of the Fund.

8. *Cases.*—No. 281. Widow, aged 53. Two sons, aged 22 and 15. Receiving £1 per week. Professor P. E. Mullaney reported that the Veterinary Medical Association of Ireland's Scrutinizing Committee strongly recommended that the grant in this case be not disturbed for a further 12 months. In the meantime he would make enquiries about the youngest boy's scholastic attainments and report to the next meeting. It was agreed that the grant be continued for a further year.

No. 275. Widow, aged 50. Two sons, aged 20 and 18, latter partially paralysed. Case reconsidered as grant expired in September. After much discussion, it was resolved:

(i) That the grant of £3 per week be continued for the time being.

(ii) That a member of the Ladies' Guild be asked to visit this recipient.

No. 295. Widow, aged 41. One child, aged six. The Secretary reported that in June last the Council decided, in view of her appointment as housekeeper to a doctor, that the grant be reduced from £3 to £1 per week for the three months ending September, and that the case be further reviewed at the next meeting. Further consideration having been given to this case, it was resolved that the grant be now stopped.

No. 299. Widow, aged 60. The Secretary submitted correspondence in this case which greatly impressed the meeting. It was resolved that the grant of £3 per week be continued for another six months after which it be further considered.

No. 304. M.R.C.V.S. The Executive Committee reported the action taken in this case, in response to the member's urgent appeal for financial assistance, which was confirmed. The Council however, expressed the view that should a further appeal be received from this member that enquiries as indicated by the Council be made before further help is given.

No. 305. Widow, aged 58. Three married daughters, unable to help, and one son, aged 29. It was agreed that the grant be continued for a further six months at the end of which the case be again reviewed.

No. 252. Widow, aged 80. Receiving £1 per week. The Secretary reported:

(i) That this recipient died on September 14th last.

(ii) That her daughter, who had been nursing her mother during her last years, was herself a sick woman and receiving hospital treatment. Being without means, she had submitted an application for assistance.

Professor P. E. Mullaney informed the meeting that he personally called on the applicant a few days ago, and in his opinion the case was a very worthy one. It was thereupon resolved that a grant of £1 per week be made in this case.

New Cases.—It was resolved that action in regard to the four other cases on the Agenda be deferred to the next meeting.

9. *Date of Next Meeting.*—It was agreed that the date of the next meeting be left in the hands of the Executive Committee and that if possible it be held in the week of the R.C.V.S. Quarterly Meetings.

Current Literature

BOOK REVIEW

Broilers, their Production and Management. ERIC F. GOLDEN. Published by *Poultry World*. 1st edition. October, 1955. 96 pp., 23 illus., paper cover. Price 4s. 6d.

This is the first account of broiler production in Great Britain and therefore must be of considerable value to those members of the profession interested in this recent development of the table poultry industry. The writer, who is regarded as one of the most successful exponents of table poultry production, has drawn not only on his own lifetime experience in this country, but also on the extensive knowledge which he gained during a tour of the broiler producing areas of the United States.

The subject is dealt with clearly and concisely under the headings of Production Policy, The Broiler House, The Broiler Chick, Equipment, Management, Feeding for Meat, Disease Control, Raising Broilers in Cages and Selling the Final Product.

In the main, this booklet is highly informative, and it is only when the author is diverted into technical problems such as nutrition and disease that the subject matter becomes somewhat sketchy and in places naïve.

The booklet is written in a most refreshing and readable style and for the main part as an account of personal experiences. The author quite rightly draws attention to the numerous pitfalls likely to beset this highly intensive form of stock management and the associated problems of marketing the end-product. Broiler production is likely to become "big business" and the author stresses the need for organisation if a young and inexperienced industry is not to be squeezed out of business.

As the foreword states, the author would be the last to expect that his writings are "final." Nevertheless the book provides fundamental knowledge of this new and absorbing branch of agriculture and veterinarians will do themselves and the profession a disservice if they fail to read it.

R.C.V.S. LIBRARY ACCESSIONS

Books and Pamphlets

MALAYA. Institute for medical research. Kuala Lumpur. Rabies in Malaya by C. E. Gordon Smith and C. W. Wells. Kuala Lumpur, Govt. Press, 1955.

MARTINEZ, C. R. La medicina veterinaria en la Edad Media. Caracas, Min. Agric. y Cria, 1948.

MAY, N. D. S. The anatomy of the sheep, with instructions for its dissection. Brisbane, University of Queensland Press, 1955.

PARISH, H. J. Antisera, toxoids, vaccines and tuberculins in prophylaxis and treatment. *Third edition*. Edinburgh, Livingstone, 1954.

PARREIRA, L. L. Normas cientificas da alimentaçao. Porto, Imprensa Social, 1955.

Reports

AUSTRALIA. *Commonwealth Scientific and Industrial Organisation*. Analysis of Merino Stud Flocks (Bulletin No. 276), 1955.

BECHUANALAND PROTECTORATE. *Department of Veterinary Services*. Annual Report, 1954, 1955.

CANTERBURY (N.Z.). Agricultural College Annual Review, 1955.

COMMONWEALTH AGRICULTURAL BUREAUX. Twenty-Sixth Annual Report, 1954-55.

KENYA. *Department of Veterinary Services*. Annual Report, 1954

NEW SOUTH WALES. *Department of Agriculture*. Livestock Health and Animal Husbandry Report, No. 29, year ended June 30th, 1953. 1955.

PUNJAB. *Animal Husbandry Department*. Annual Report, 1952-3. 1955.

SOUTH AUSTRALIA. *Institute of Medical and Veterinary Science*. Sixteenth Annual Report, July, 1953—June, 1954.

TRINIDAD AND TOBAGO. *Director of Agriculture*. Administration Report, 1954.

UGANDA PROTECTORATE. *Department of Veterinary Services and Animal Industry*. Annual Report, 1954.

News and Comment

PROCEEDINGS OF CONGRESS

As mentioned in a recent issue of THE RECORD, we publish, this week, the full Papers and discussions of the 1955 Belfast Congress in a single, supplementary number. Readers will notice that the pages have been so arranged that, when this week's two copies are bound, the pages follow on one from the other without interruption.

It is hoped that this innovation, made necessary by the growing size and importance of Congress, will be generally welcomed. It should add usefully to the Association's archives, and also make for easier reference when Papers, or the discussions deriving from them require to be consulted in future years.

PROFESSOR J. J. O'CONNOR

The death, on November 8th, 1955, of Professor J. J. O'Connor has removed from our midst one of the most prominent members of the profession in these islands.

He was born in 1874 on a big farm at The Ward, Co. Dublin, and educated at Terenure and Castleknock Colleges and the Royal University, Dublin. Like many other farmers' sons he took up the study of veterinary science, qualifying at the Royal Dick College, Edinburgh, in 1899. After graduation he acted as house surgeon and lecturer in stable management at the "Dick," until he joined the R.A.V.C. in 1901, in which service he supervised transport of horses by sea from many ports to South Africa during the Boer War.

In 1902, at the invitation of Principal Mettam, who had noted his operative skill as house surgeon in Edinburgh, he accepted an appointment as Professor of surgery at the newly established Veterinary College of Ireland, Ballsbridge. In 1935, he was appointed Principal of the College, a post he held until his retirement in 1941.

To the counsels of the profession, Professor O'Connor contributed unsparingly. He was honorary secretary of the Veterinary Medical Association of Ireland for 20 years, and was twice its President. He was the first President of the Veterinary Council of Ireland, and contributed papers, and carried out surgical demonstrations at many meetings not only in Ireland, but also in Britain.

He was a courageous and most successful surgeon, not only on the larger animals, but on small ones as well, and his services were in great demand as a consultant.

As a teacher, he was most painstaking, being beloved by his students for whom he spared no trouble, being ever ready to help and advise. His great operative skill has not all died with him, for in every land where his students live he has left behind a group of able surgeons whose work is of the greatest value to the agricultural communities they serve. We have often been impressed by the skill shown by some of his pupils at operations at meetings and congresses, and the records in the professional journals of some of their work is further evidence of the influence their great surgeon-teacher had upon them.

It was surprising how Professor O'Connor managed to keep in touch with his students after graduating. No matter where they went he seemed to keep himself informed of their progress, and retained an interest in them at all times.

Those who studied under Professor O'Connor were very fortunate. Not only did they study under a great master of his subject, but also under a man of the highest character and personal charm. Sincere, kindly and gentle, he had the humility of greatness, and part of his fine personality must have passed on to each and every one of his students to influence them for good. It will be hard to find his like again.

We shall all miss him, but most of all those near and dear to him; his daughter, Mrs. A Donnelly, and his sons, Mr. J. D. O'Connor, M.A., M.R.C.V.S., and Mr. D. J. O'Connor, B.A., LL.B., who have all our sympathy. J. D. W.

H. B. writes:—

It is many years since I "sat at the feet" of the late Professor J. J. O'Connor in what was then the Royal Veterinary College of Ireland. As I read the news of his death in THE VETERINARY RECORD I recalled the impression he had made upon me in those far-off days, and I fell to wondering whether in years to come his name would rank with the great ones of our profession.

"J.J.," as he was known to his students, certainly never sought the limelight, nor was he famed for classical rebuffs to his students. On the contrary, when addressing a class in a lecture room or in a clinic one would almost detect a certain shyness; he spoke deliberately and quietly, and he was seldom ruffled. Sometimes during a lecture he would gaze out of a window for the space of half a minute or so, apparently oblivious of the class in front of him, and then, turning to some student would ask, "Mr. So and So, what were we talking about?" The question was posed in such a tone of voice as to suggest that he was in need of a prompt, but one often wondered if in fact this was the case.

It may seem presumptuous for such as I to pass comment on the surgical technique practised by the mighty. I have seen quite a number of people at work, however, and although it is many years since I saw "J.J." operate, my impression is that his technique may have been devoid of flourish but it was nevertheless sound and speedy and left no doubt in the mind of the onlooker that this surgeon practised what he preached, namely, "to find the cause and remove it!" Since I was in his class, I have met many young graduates, and I have come to realise that his great strength lay in the importance which he attached to the preparation of his students to enable them to undertake responsibility in general practice. In discussing methods of procedure in

surgical operations he frequently referred to those adopted by practitioners in various parts of the country. He would learn from anyone who had anything to teach him, and he would explain a method whether he favoured it himself or not.

Looking back on those days I think that the Dublin students were singularly fortunate in their teachers, for they had the late Professors Craig, O'Connor and Keogh, and Professor T. G. Browne (happily still with us), all of whom were in the forefront of their particular spheres.

THIS PLAQUE IS TO COMMEMORATE
THE OPENING OF THIS HOUSE AS
BRITISH VETERINARY ASSOCIATION
HEADQUARTERS BY HIS GRACE
The DUKE OF NORFOLK KG PC KCVO
ON 22nd JANUARY 1954

The handsome plaque which is photographed above was erected recently in the main front hall of the Association's Headquarters.

FRENCH STUDENTS

A second-year French veterinary student in Toulouse is anxious to obtain accommodation with a British veterinary surgeon to live with the family as a paying guest for about three weeks between July 10th and September 1st, 1956. He is particularly interested in horse and cattle practice, and he has seen some practice in France.

A 21-year-old daughter of a French veterinary surgeon would also like to spend the Easter holidays *au pair* or as a paying guest with a veterinary family in the London area. If any members are in a position to help these students would they kindly communicate with the General Secretary, B.V.A., at 7, Mansfield Street, Portland Place, London, W.1.

B.V.A. COUNCIL AND COMMITTEE MEETINGS IN LONDON

Wednesday, January 18th, 1956

10.30 a.m.—Home Appointments Committee, at 7, Mansfield Street, W.1.

12.00 noon—Parliamentary and Public Relations Committee at 7, Mansfield Street, W.1.

2.15 p.m.—Organising Committee, at 7, Mansfield Street, W.1.

Thursday, January 19th, 1956.

10.00 a.m.—Veterinary State Medicine Committee, at 7, Mansfield Street, W.1.

12.00 noon—Finance Sub-committee, at 7, Mansfield Street, W.1.

2.15 p.m. General Purposes and Finance Committee, at 7, Mansfield Street, W.1.

Friday, January 20th 1956.

10.30 a.m.—Meeting of Council at Connaught Rooms, Great Queen Street, W.C.2.

THE REGISTER OF VETERINARY SURGEONS

Under Section 25 (3) of the Veterinary Surgeons Act, 1948, and the provisions of Statutory Instrument No. 1150 of 1953, the under-mentioned name has been removed from the Register of Veterinary Surgeons:—

Wilson, Peter Frost, of Alford, Aberdeenshire.

PERSONAL

Births

DAVIES.—On November 20th, 1955, to Peggy, wife of J. Ifor Davies, M.R.C.V.S., of Ardwyn, College Road, Carmarthen, a daughter, Tegwen Sian, sister for Geraint.

MAYNARD.—On November 30th, 1955, to Evelyn (*née* Gay), wife of Harvey Maynard, M.R.C.V.S., at 95, Damers Road, Dorchester, a daughter, Ann Elizabeth.

SCOTT.—On November 29th, 1955, to Pat (*née* Sharp), wife of A. M. Scott, M.R.C.V.S., Forton Road, Newport, Salop, a sister for Kevin.

THOMPSON.—On November 26th, 1955, to Elsa, wife of Peter K. Thompson, of Goole, Yorkshire, a son, Charles Fraser, brother for Susan and Angus.

Marriage

CLOW—WILSON.—At Newlands (South) Church, Glasgow, on Saturday, December 3rd, 1955, David Gordon Clow, M.R.C.V.S., son of Mr. and Mrs. W. T. Clow, 4, Priestfield Road, Edinburgh, to Jean Stewart Wilson, M.C.S.P., daughter of the late Dr. and Mrs. A. Stewart Wilson of Durban, South Africa.

R.C.V.S. OBITUARY

We record with regret the death of the following member of the profession:—

LEVIE, Alexander, of "Overfields," Quarndon, Derby. Graduated Edinburgh, April 16th, 1887; died December 5th, 1955, aged 91 years.

COMING EVENTS

December

14th (Wed.).. Special Laboratory Meeting of the Section of Comparative Medicine, R.S.M., at the Royal Veterinary College, Royal College Street, Mornington Crescent, N.W.1, 4.30 p.m.

29th (Thurs.). Annual Dance of the V.V.B.F. Ladies' Guild, Dumfries and Galloway Division, in the Cairndale Hotel, Dumfries.

January, 1956

5th (Thurs.). General Meeting of the Central Division, B.V.A., at the Royal Veterinary College, Camden Town, N.W.1, 6 p.m.

6th (Fri.). Annual Dinner and Dance of the North Wales Division, B.V.A., in the Imperial Hotel, Llandudno, 7 p.m.

Sixteenth Ordinary General Meeting of the A.V.T. and R.W.s at the Royal Veterinary College, Camden Town, N.W.1, 10 a.m.

11th (Wed.). General Meeting of the Lancashire Division, B.V.A., at the Queen Hotel, City Road, Chester, 2.30 p.m.

R.C.V.S. EXAMINATIONS

December 12th, Monday.—M.R.C.V.S. Practical and Orals commence (Panels "A" and "B").

ADDRESSES OF DISEASE INFECTED PREMISES

The list given below indicates, first, the county in which are situated the premises on which disease has been confirmed, followed by the postal address and date of outbreak.

Anthrax

Anglesey. Hafod Farm, Tynlon, Holyhead (Nov. 30).

Derby. Coppice Farm, Cubley; No. 2 Holding, Broadholme, Belper (Dec. 1).

Fife. Balone Dairy Farm, St. Andrews (Dec. 2).

Montgomery. Glyn Farm, Llanidloes (Nov. 30).

Perth. Burnside Farm, Stanley (Dec. 1); New Farm, Collace (Dec. 2).

Shrops. Cherrington Grange, Newport (Nov. 29); West View Farm, Farm Lane, All Stretton, Church Stretton (Dec. 5).

Staffs. Bearstake Farm, Sandon Road, Hilderstone, Stone; Knighton Mount Farm, Adbaston (Nov. 30); Hinkaford Farm, Kingswinford, Brierley Hill (Dec. 2).

Yorks. Whinmoor Farm, West Healerton, Malton (Dec. 2).

Fowl Pest

Essex. Bulpham Poultry Farm, Bulpham, Upminster (Nov. 29); Greengates, Brick Kiln Lane, Great Horkesley; Bellers Bungalow Terrace, Hall Chase, Great Horkesley, Colchester (Nov. 30); Great Horkesley Manor, Colchester (Dec. 2); 193, Southend Road, Rochford (Dec. 4).

Glamorgan. Tyrhos Farm, Llwydcoed, Aberdare (Dec. 3); Penpwyn Farm, Treeynon, Aberdare (Dec. 4).

Gloucs. The Fosseway Hotel, Bourton-on-the-Water, Cheltenham (Dec. 2).

Hereford. Stretford Court, Stretford, Leominster (Dec. 3).

Herts. Cromer Hyde Piggeries, Welwyn Garden City (Dec. 3).

Kent. Harbourne Farm, High Halden, Ashford (Dec. 3).

Lancs. Brigg Brown Bungalow, Thurnham, Glasson Dock, Lancaster; Conder Green, Lancaster; Clifton Poultry Farm, Longton, Preston; Lime Ditch, Off Gas Street, Failsworth, Manchester; 31, Samuel Street, Middleton, Manchester (Nov. 29); Newlands, Hothersall, Longridge Preston; 1, Fishwick Lane, Higher Wheelton, Chorley; Hinclough Farm, Ainsworth, Bolton; Westridge, Ainsworth, Bolton; Hala Carr Farm, Sootforth, Lancaster; Moss Side Farm, Cookerham, Lancaster; Clevelands, Forton, Preston; Brooklands, Stryands Lane, Hutton, Preston; Briarfield, Liverpool Road, Hutton, Preston; Grimeford Lane, Anderton, Chorley; Cams Acre Farm, Bolton Road, Radcliffe; 7, Knight Street, Ashton-under-Lyne (Nov. 30); Milner Street, Radcliffe, Manchester; White House Farm, Moss Lane, Much Hoole, Preston (Dec. 1); Fox Croft, Gill Lane, Longton, Preston (Dec. 2); Laburnham Cottage, Forton, Preston (Dec. 3); Gill Farm, Gill Lane, Longton, Preston; Sunnydale Poultry Farm, Grimeford Road, Blackrod, Chorley (Dec. 4).

Norfolk. High Noon Farm, Acle, Norwich; Moss Allotments, Cobholm, Great Yarmouth; The Street, Corpusty, Norwich; Mill Hill, Corpusty, Norwich; Elveden, Barnham, Thetford; Gun Street, Foulsham, East Dereham; Norfolk Agricultural Station, Sprowston, Norwich (Nov. 29); The Farm, Lyng, Norwich (Dec. 2); The Lodge, Winfarthing, Diss (Dec. 3); 2, Boddys Road, Gun Street, Foulsham, East Dereham (Dec. 4).

Shrops. Banks Farm, Wolverley, Wem (Nov. 30).

Staffs. The Poultry Farm, Paget Road, Wolverhampton (Nov. 30); Small Heath Farm, Claverley, Wolverhampton (Dec. 2).

Suffolk. Townsend Farm, Chilton Road, Clare, Sudbury (Nov. 30).

Sussex. The Allotments, Castle View, Rye Harbour, Rye; The Manor House, Icklesham, Winchelsea (Dec.4).

Yorks. 747, Huddersfield Road, Austerlands, Oldham (Nov. 29).

Swine Fever

Cambridge. Causeway Farm, Sutton, Ely (Dec. 2).

Ches. Barlow House Farm, Poyton, Stockport (Dec. 6).

Derby. 112 Emmett Carr, Renishaw, Sheffield (Nov. 30).

Devon. Rose Cottage, Preston, Kingsteignton, Newton Abbot (Dec. 5).

Dorset. Childeock, Bridport (Nov. 30); New House Farm, Loders, Bridport (Dec. 2); Pear Tree Farm, Halstock Leigh, Halstock, Yeovil; Little Burton Farm, Leweston, Sherborne (Dec. 5).

Essex. Highwoods Farm, Halstead (Nov. 29).

Hants. 120, Muscliffe Lane, Troop, Bournemouth (Dec. 3).

Kent. Haine, Ramsgate (Nov. 30).

Lanarks. East Kilbride, Glasgow (Dec. 1); Wester Cleddens, Lenzie, Glasgow; Milton Piggeries, Provanmill, Glasgow (Dec. 3).

Lancs. Avondale, Tower Lane, Fulwood, Preston (Dec. 2).

Norfolk. New Garden Allotments, Salters Road (Dec. 5).

Rutland. Stones Farm, Ashwell, Oakham (Nov. 30).

Somerset. Coombe Farm, West, Crewkerne (Dec. 3).

Staffs. Broadmeadow Farm, Butterton, Leek (Nov. 29).

Sussex. Racehill, Brighton (Nov. 30).

Yorks. 147, Batley Road, Kirkhamgate, Wakefield (Dec. 1); Hasting Street Allotments, Grimethorpe, Barnsley; Taylor Hall Farm, Taylor Hall Lane, Mirfield; Dankfield Farm, Southowram, Halifax; Margate Street Allotments, Grimethorpe, Barnsley (Dec. 3); Dingle Farm, Marsh, Huddersfield (Dec. 5).

CORRESPONDENCE

The views expressed in letters addressed to the Editor represent the personal opinions of the writer only and their publication does not imply endorsement by the B.V.A.

THE PROFESSION AND THE PRESS

Sir,—Your article in the News and Comment section of last week's RECORD on the above subject does not get at the throat of the problem. The last paragraph, in which you quote the Chief Secretary of the R.S.P.C.A. in order to show that "the picture is not wholly dark," is especially depressing.

Mr. Moss of the R.S.P.C.A. states that the B.V.A. press and publicity liaison is good because after the newspaper publication of the last Congress "there was a bombardment of press calls" at his home and office. When the press telephone the R.S.P.C.A. headquarters, of all places, about our Veterinary Congress affairs, then surely this is the final humiliation. Animal protection society matter is to be seen in the press almost daily so that pressmen cannot be blamed for thinking that the veterinary profession is a kind of subsidiary of the R.S.P.C.A. We are discouraged to see the B.V.A. press liaison committee so easily pleased by Mr. Moss's letter.

The fact that a man of Dr. Wooldridge's calibre has been advocating improved press liaison for 14 years with little result, may indicate that the profession as a whole is not interested in this problem. How much, for example, did *The Farmer and Stock-breeder* affair interest the academic research and Ministry branches of the profession? Are some of us practitioners, in their view, making a fuss about nothing?

Mr. McGee says that the policy of the present B.V.A. press liaison "is in itself sound and worthy of the approval of all members of the profession." Most members will support both him, Dr. Wooldridge and Mr. R. I. Macrae in their appreciation of the good work done by our President in the matter of *The Farmer and Stock-breeder's* anti-veterinary publication. As Mr. Macrae points out, however, it is doubtful whether the continued hushing up of these negotiations is desirable. The *Stock-breeder's* comments were outspoken enough and farmers would not think adversely of a profession which says what it thinks.

Several writers suggest that a full time press liaison officer be appointed. Mr. Mercer comments that press liaison at the moment constitutes a minor part of the work of the present officer, a situation which illustrates the small importance the profession has hitherto placed on press relations. The fact that the present officer has found any time at all for press liaison is a tribute to him.

The correspondence so far in THE RECORD about the Profession and the Press seems to us to warrant more than a "steady boys, steady" article in the News and Comment, and we look forward to some official comments and plans for the future.

Yours faithfully,

A. K. KIRKWOOD.
J. C. MEIKLE.

14 & 16, Queen's Road,
Reading.

December 4th, 1955.

DISEASES OF ANIMALS ACT, 1950—GREAT BRITAIN
Summary of Returns of Confirmed Outbreaks of Scheduled (Notifiable) Diseases

Period		Anthrax	Atrophic Rhinitis	Foot-and-mouth	Fowl Pest	Sheep Scab	Swine Fever
16th to 31st October, 1955		50	1	—	40	—	42
Corresponding period in	1954	20	—	—	15	—	43
	1953	9	—	1	37	—	84
	1952	104	—	—	19	—	20
1st January to 31st October, 1955 ...		630	6	6	465	—	1,224
Corresponding period in	1954	257	4	12	630	—	1,245
	1953	528	—	29	790	—	2,436
	1952	842	—	494	199	1	743

TUBERCULOSIS (ATTESTED HERDS) SCHEMES

The number of Attested Herds, *i.e.*, herds officially certified as free from Tuberculosis as at 31st October, 1955, was as follows :—

ENGLAND	WALES	SCOTLAND	TOTAL (GREAT BRITAIN)
79,540	33,667	35,489	148,696

Brucellosis Control and Eradication in Denmark

BY
F. WOLDIKE NIELSEN
Veterinaerdirektoratet, Copenhagen

AS the campaign against bovine tuberculosis approached its final stages Danish farmers began to be interested in making a similar attack on brucellosis as well. The Veterinary Directorate had foreseen that sooner or later this would be the case and had, already in 1937, made a pilot attempt on the Danish island of Bornholm as well as in certain districts in other parts of Denmark to eradicate this bovine affection.

Within the boundaries of these areas the Veterinary Directorate laid down certain lines to be followed and for a number of years followed up the resulting conditions in each herd. (In Bornholm alone this meant inspecting some 3,800 separate herds). Thus much valuable experience was gained of the efficiency of the prescribed procedures and it became possible to draw up a detailed parliamentary Bill for the eradication of brucellosis and to establish the lines to be followed by farmers and veterinary surgeons. This Bill was passed in 1948.

In the following paper I propose giving you a brief summary of the most important provisions embodied in the above Bill and of the measures given therein (A) as well as of the methods followed in the campaign (B).

(A) The Legislative Basis.

Measures instituted to prevent the spread of infection.

The term "contagious bovine abortion" (Bang's disease) is understood legally to include all forms of infection in cattle with bacteria of the brucella group.

The term "abortion" is taken to mean any expulsion of the foetus—irrespective of cause—during the period from 90 days after service or insemination up to the 265th day of gestation. Should, at calving—either prior to or at full term time—pathological alterations indicative of brucellosis be apparent, such cases will also be considered as included under the heading of abortion.

Whenever a case of abortion occurs in a herd of cattle the owner will automatically be subject to various requirements in order to prevent the spread of the infection to other herds, and the owner's right to dispose of members of his herd will be considerably curtailed. The owner must remain subject to these restrictions and unable to sell his cattle freely until certain prescribed examinations have proved that the abortion was not of an infectious nature. It should therefore be noted that cows or heifers that show signs of approaching abortion, or which have already aborted, must be kept indoors for at least a fortnight after aborting. The aborted foetus as well as the placenta and vaginal discharge must be rendered harmless by burial. Animals that have aborted, or which are expected to do so, must not be transported together with other livestock. When cattle from herds that are not abortion-free are put out to graze, the owner must prevent his animals from approaching neighbouring herds nearer than eight feet. Regulations have also been drawn up to prevent infection by animals drinking at a common watering place, *e.g.* a pond, pool or trough. On common grazings abortion-free cattle must be kept separate from infected animals and the erection of fences is made compulsory to prevent the spread of infection from or to neighbouring pastures. Should a case of abortion occur among the animals fenced in a common pasture, immediate isolation of the animal in question is made compulsory and, should it occur on a pasture for abortion-free animals, all the owners of the animals concerned must be informed.

Only such animals as originate from abortion-free herds may be sold for breeding and they may only be disposed of direct from the herd or from a recognised market or agreed commercial centre.

Special regulations have also been enacted regarding the cleansing and disinfection of cattle fairs and transport trucks.

Control of Bulls

Bulls, which are employed for the service of abortion-free cows from other herds or which are to be used for artificial insemination must, before they are utilised for these purposes, be proved free of *Brucella abortus* infection. Moreover, they must be kept only in premises where no other cattle are present or where the herd is definitely free of contagious abortion. All bulls are subject annually to the four following examinations: —

(a) a clinical examination and blood test,
(b) three months later a laboratory examination of the semen,
(c) another three months later a further clinical examination, and finally
(d) three months after this a further examination of semen.

Semen from bulls that react to brucella tests or which presents an abnormal appearance may not be used for artificial insemination. Bulls in whose semen *Brucella abortus* bacteria are present or which show clinical symptoms of brucellosis infection of the genital organs or which are suspected by the Veterinary Directorate of having infected cows or heifers must not be used for breeding purposes but must be disposed of direct to the slaughterhouse.

Finally, a number of compulsory regulations have been enacted regarding the observation of the strictest possible care in the collection and handling of semen and in carrying out artificial insemination.

State support for the Campaign by the Treasury

In various ways the State contributes useful support to the campaign financially. It is a condition of such support, however, that the campaign be carried through in accordance with the lines laid down by the Veterinary Directorate.

Grants for diagnostic examinations. The milk from every herd in Denmark is subjected to four laboratory tests annually (A.B.R.). These, as well as the yearly and half-yearly blood tests which have been required by the Veterinary Directorate as part of the systematic campaign are paid in full by the Treasury. A grant is also allowed for covering payment of up to half the cost incurred by the veterinary surgeon in taking blood samples.

Grants for killing brucellosis infected animals. By taxing exports of live cattle and of meat a fund has been created from which payments may be made to subsidise the killing of brucellosis infected animals.* Within certain limits the State subsidises this fund. Contributions from the fund are allowed in the case of slaughter of animals over one year old which show a positive reaction to the blood test or which have aborted as a consequence of brucellosis.

As a general rule allowances have been made for some 20 animals per herd per annum at the most. The size of the allowance is kr. 100 (£5) for animals over two years old and kr. 50 for animals between one and two.

During the first few years after the campaign against contagious abortion had been properly organised, these allowances could be obtained anywhere in Denmark. But in order to accelerate eradication, the allowance was later limited to herds belonging to Dairy-member groups, which had fixed a certain time limit (three years at most) within which all their herds should be free of brucellosis. (For "campaigns-by-district" by Dairy-member groups see later paragraph.)

Should such a dairy decide to contribute an allowance for the clearing up of herds which, within or after the end of the agreed period, became infected or re-infected, the Dairy can obtain a refund of up to half the cost from the Treasury.

Registration of brucellosis-free herds.
Sale of brucellosis-free animals, etc.

It is the duty of the central Federation of the Danish Dairy Associations to register all herds which the Veterinary Directorate, on a basis of the diagnostic examinations, etc., available, can accept as free of contagious abortion.

In order that a herd shall qualify for registration the Veterinary Directorate requires (1) that no reaction be evident at the four previous A.B.R. tests (taken at quarterly intervals) and (2) that a blood test be carried out in the case of animals aged one year or more, two to six months after the last milk test.

Furthermore it is essential that no vaccination has been undertaken during the period while these tests were being made, and that no new animals had been added to the herd which might introduce some danger of infecting the herd. After registration the herd is controlled solely by the quarterly A.B.R. tests.

In acquiring new animals for a registered herd it is a *sine qua non* that these originate from another registered herd and that they be accompanied by a Veterinary Certificate, of a type prescribed by the Ministry of Agriculture.

*The tax amounts to 2 re. per kilo meat and kr. 5 per living animal.

No seller is allowed to designate an animal as "free of contagious abortion," "free of reaction to contagious abortion," "sound as a bell," or similar expressions which might lead the buyer to assume that the animal in question is free of contagious abortion unless the animal really comes from a registered herd and has not been exposed to infection. Should the buyer require a document certifying that the animal is free of contagious abortion, the seller may only supply the type of Veterinary Certificate described above.

The Dairy Member-Groups' Campaign by District

Just as in the campaign against bovine tuberculosis the procedure in combating contagious abortion has been arranged by dairy member-group districts.

Between 90 and 95 per cent. of our milk in Denmark goes through our co-operative dairies. The member-groups of these dairies are entitled, in accordance with the rules of their Association, to introduce and carry through any measure that may be expected to improve the quality of their milk. Among such measures the eradication of chronic infectious diseases is one of major importance.

The rules, which are binding on all members, provide for (1) diagnostic examinations of herds; (2) the registration of all healthy herds when they fulfil the necessary requirements, and (3) the taking of measures among infected herds strictly in accordance with the regulations laid down by the Veterinary Directorate.

Furthermore, the members of such a dairy may agree at any time during the campaign that before the lapse of the maximum time-limit of three years all the herds of the members must be freed from contagious abortion. Should this object not be realized special steps would be taken to accelerate the eradication of disease in their herds. These measures may be of various kinds. For example, after the lapse of the aforesaid time-limit the owner of an infected herd will receive less payment for his milk than the owner of a brucellosis-free herd. Moreover, the milk from an infected herd may not be collected and driven to the dairy by the usual collecting truck, but the owner must at his own expense transport his milk to the dairy after the milk from the healthy herds has been duly dealt with. This arrangement is extremely effective among Danish farmers, for when treated thus they feel themselves shut out from the farming community. As a rule no one is psychologically able to withstand this pressure for long and they greatly prefer to do what they can to get rid of the infection with all speed.

In dairy zones where a time-limit for eradication has been duly set, whenever an abortion occurs in a brucellosis-free herd, samples of blood and of placenta must be sent for laboratory examination. All expenses incurred both by the veterinary surgeon and by the laboratory are paid by the Treasury.

Most dairies in Denmark have voluntarily fixed a time-limit for definite eradication and, as far as the remaining few are concerned, the Minister for Agriculture is himself empowered to fix a time-limit. Such a declaration can only be made, however, provided the majority of dairies—90% in larger islands and land areas—have already set a time-limit for eradication.

Vaccination

While brucellosis infected animals may not be treated unless the remedy in question has been approved of by the Veterinary Directorate for this purpose—and such approval has in no case been given as yet—vaccination is permitted, but only to a limited extent and only after permission has been obtained from the Veterinary Directorate for each individual herd.

Permission is given only to owners of herds in which brucellosis infection has been proved, either by examination of the placenta or by a blood test undertaken at the State Veterinary Serum Laboratory. Permission is valid only for a three year period. Should it be desired to continue the vaccination further, a fresh application must be made.

At the first vaccination all non-pregnant heifers and all heifer calves of five months of age and upwards must be treated. The vaccinations will then be continued with the heifer calves as they successively reach the age of five to seven months.

In herds in which cases of contagious bovine abortion appear, the Veterinary Directorate may allow vaccination of non-pregnant cows which have not aborted and which show no reaction to a blood test. Permission to vaccinate will, however, only hold good for a single year at a time.

All vaccinations of cows and heifers must be concluded at least three months before service.

(B) Directional Lines for the Eradication Campaign.

When a dairy member-group has decided to embark on a campaign against contagious abortion the work is usually started by an exploratory milk examination (A.B.R.). Herds in which the milk reveals a reaction then undergo a blood test in order to reveal the extent of the infection.

According to the result of these examinations the herds may be divided into the following groups:—

(1) Herds which show no reaction to contagious abortion,
(2) Herds which react to contagious abortion, but in which clinical abortion has not occurred—at any rate not during the previous year, and
(3) Herds in which clinical abortion occurs.

In the following section are summarised the main points of the instructions which the Veterinary Directorate has worked out for the use of owners of herds and for veterinary surgeons in the campaign against contagious abortion in the above three herd categories, and which the herd owners are in duty bound to follow.

1. Owners of herds in the first group are advised to continue with the diagnostic examinations in order to ascertain whether their herds are really free from contagious abortion and to have them enrolled as soon as possible in the register of abortion-free herds. Every owner is also constrained to carry out a number of precautionary measures designed to prevent the infection of his herd from outside. The conditions to which special attention is drawn as being particularly dangerous are (i) when purchasing new additions to the herd, (ii) when employing visiting bulls for service purposes, (iii) infection by neighbouring herds while grazing, (iv) letting herds graze on a common pasture ground, (v) contact with persons, poultry, dogs, etc., from infected farms and (vi) purchasing feeding stuffs in foreign, second-hand bags. Finally, detailed advice is given as to what to do in case of the sudden appearance of abortion in the herd, *e.g.*, the removal and examination of the placenta, taking a blood test, isolating the animal which has aborted, and the cleaning up and proper disinfection of the premises afterwards.

2. With regard to the second herd group it is of the greatest importance to ascertain by repeated blood tests the spread and course of the disease. Should the examinations show but few reacting animals, it may be assumed that the disease is not present in an active form. It is therefore advised to sell the reacting animals (especially those that show a blood titre of 1/100 or over) or to isolate them provisionally by removal from the cowshed until they can be sold. After the sale of the reacting animals has been effected, examinations by means of milk and blood tests should be continued with the object of eventually being able to enrol the herd in the above register.

If, on the other hand, so many animals react to the first blood test examination that they cannot be quickly disposed of, these reacting animals should be segregated in the cowshed in a group by themselves. This partial isolation is usually effected best by placing the infected group nearest the outlet of the dung channel. If it is possible to leave a couple of stalls empty between the infected and non-infected animals or to reserve one or more rows of stalls solely for the infected animals it would be of advantage. The drainage channel behind the infected animals should be swilled daily with a 5 per cent. solution of chloride of lime.

When a reacting animal is about to calve, or shows signs of aborting, complete isolation of the animal (calving isolation) must be effected during the period from three to four days before till at least a fortnight after calving or aborting. Animals that have not reacted should also be isolated if they show signs of aborting or calving prematurely.

The calving-isolation will naturally best fulfil its object if it is effected outside the cowshed. However, it is often necessary to make use of a box within the cow-shed itself. If the box be separated from the other stalls by a 6 ft. partition, and if the urine and manure can be removed without soiling the healthy animals or their stalls, an isolation of this kind within the cowshed may well function satisfactorily. It is, of course, essential that everything must be kept meticulously clean and that chloride of lime be frequently swilled behind these animals. In any case it cannot be too highly recommended to keep the shed and stalls at all times perfectly clean and after each washing to treat the drainage channel with a disinfectant mixture.

However careful one may be, however, in trying to isolate animals that excrete infective matter and in destroying it, the risk of infection is always present and in consequence it is strongly advised that the calves in these herds be vaccinated in order to increase their resistance. These vaccinations must be systematically carried out.

It should be emphasized, however, that vaccination is by no means a panacea in the fight against contagious abortion. If one does not carry out the measures des-

cribed above of isolating the aborting or calving animals, of burying the aborted foetus and placenta, and of meticulous cleansing and disinfection of any place where the infective matter is deposited, etc., in fact, if one does not do everything possible to prevent the spread of infection within the cowshed, the immunity gained by vaccination will, in many cases, be broken down and the animals in question will become infected. Only when vaccination is employed in conjunction with the sanitary measures outlined above will it be of real assistance to one's efforts to clear a herd of the disease.

3. The third group comprises herds in which clinical abortion appears or has made its appearance within the previous 12 months.

(a) *Recently infected herds*

If in a hitherto abortion-free herd a case of contagious abortion suddenly makes its appearance the herd as a whole is thus laid open to considerable risk of infection.

If the animal in question has been isolated in time and the various disinfecting measures are rigorously carried out one may possibly succeed in some cases in preventing further spread of the disease. The *modus operandi* is as follows:—

Animals that show signs of aborting are isolated immediately and are sold as soon as a laboratory examination has established that the abortion is of an infectious nature. A thorough cleaning and disinfection of the whole cowshed and especially of the isolation box or stall and of tools, etc., is then undertaken. The members of the herd that are over one year old are blood-tested and if this examination shows that there are a number of reactors it is considered useless to try and hinder further spread of the disease by selling off the infected animals, but all measures described under (b) should be continued nevertheless. If, on the contrary, the blood test shows a negative result one should continue with the monthly blood test examinations until further notice but, naturally, only so long as these examinations yield a good result, *viz.*, no or only very few reactions. Vaccinations should be begun as soon as it is evident that the abortion was of an infectious nature or where the blood tests show that the disease is spreading in the herd. The vaccinations must be systematically carried through in accordance with the above-mentioned directions.

Should several cases of clinical abortion appear, or if the reacting animals are not sold, there is danger of widespread dissemination of infection in the herd and it is necessary to advise the owner to proceed in accordance with the rules given below for treating heavily infected herds.

(b) *Heavily infected herds in which during recent years several cases of contagious abortion have appeared*

In these herds the object of the work is to make the disease quiescent. The spread of infection must be retarded in every way possible and the herd's power of resistance increased by vaccination.

It is therefore evident that all infected animals must be isolated from three to four days before until at least a fortnight after the calving or abortion and this arrangement must also be carried through with each and every animal in the herd which exhibits signs of impending abortion or of calving prematurely. Similarly, by means of frequent washing and disinfection one tries to lessen the danger of infection in the herd. Systematic vaccination should be carried through as described above.

To compensate for the dearth of young animals in their herds, farmers are advised to buy calves and young animals less than a year old. These should be vaccinated immediately on arrival.

Only when clinical abortions have ceased, and it has been proved by repeated blood tests that the further spread of disease has been stopped, can it be advised to begin selling off the reacting animals—in the first place of those animals showing the greatest reaction, with a titre of 1 : 100 or more.

Since the introduction of the procedure outlined above the campaign against contagious abortion has made great progress in Denmark. When, in 1946, the work began to assume a wide scope it could be seen that roughly 25 per cent. of Danish herds were infected. In a statement published in the autumn of 1954 the number of infected herds had, however, gone down to 2.4 per cent. and at the present moment (March, 1955) it may be taken that there are even less than 2 per cent. left.

Most of the time-limits for eradication will expire during the present year or in the beginning of 1956. Only in the case of a single district will the time-limit not run out until May, 1957, the dairies there having been a little slow in making a start.

It may thus be expected that Denmark, in the course of a few years, may be declared entirely free of contagious abortion.

Incidentally it may be mentioned that the number of human beings having proven undulant fever is rapidly going down, for while in the first half of the forties, according to information given by the Ministry of Health, an average of 325 cases a year was quite usual, the number in 1952-53-54 was down to 126, 70 and 35 cases respectively.

When in 1937, we commenced our attempts in the Danish island of Bornholm (mentioned in the introduction) to fight contagious abortion the exploratory blood tests then made gave a reaction to contagious abortion in 1,259 out of 3,790 herds present in the island, *i.e.*, as much as 33.2 per cent. of the cattle population was infected.

Even during the time it took to make the survey large numbers of herds, which had shown no reactors during the exploratory tests, became infected—in most cases this also happened during one or more later investigations. In a statement drawn up at the end of 1942 it was shown that between 1937-42, 461 formerly sound herds became infected, so that the number of infected herds the Veterinary Directorate worked with in Bornholm in those years totalled in all 1,720 herds, *i.e.*, 45.4 per cent.

So large a number of new infections while carrying out our work has, however, not been recorded anywhere else in the country. This was doubtless partly due to the fact that in this island, in contrast with other trial areas, we had to do with so active an infection that one might easily have been led to believe that it was in fact a case

of quite another illness, and partly because, on account of our test plan, we wished to concentrate on our investigations and did not make much use of compulsory speeding-up measures.

By far the most common reason why a formerly brucellosis-free herd became infected was simply the promiscuous way in which new additions to herds were purchased. We are, therefore, of opinion that our provisions regarding the regulation of the cattle trade (*e.g.* the rule that a special permit form be used when making new additions to a brucellosis-free herd; the establishment of special markets for brucellosis-free animals, etc.) are definitely extremely important.

Until April 1st, 1954, it was possible to sell an animal which reacted to contagious abortion for breeding, but when the campaign against contagious abortion started practically simultaneously all over the country the demand for brucellosis-free animals emanating from brucellosis-free herds was greatly increased and at the same time the chance of doing business by purchasing reacting animals for breeding purposes was considerably reduced.

Even if this buying of infected animals was, as I said before, an important factor there are other sources of infection that should be mentioned such as, for instance, direct contact with infected herds which may take place when the fences between two neighbouring fields are too insecure to prevent the animals from breaking through and mingling together. Also breeding intercourse and artificial insemination (when preventive measures are not properly carried out) play their part in spreading infection, and direct contact between persons who move freely among sound and infected herds should not be disregarded. Dogs (and foxes) drag aborted foetuses and infected placentae about and are thus the cause of considerable danger.

Certain fresh infections have also taken place for which no cause can be proved, but it must be remembered that modern farm life with its many common interests and the consequent direct or indirect contacts between the already too closely adjacent properties provides a source of infection that is often difficult to prove, especially as the infection is often only revealed a long time after the actual transference of the infection took place.

Finally, we must not forget to mention the cost to the public of the campaign against contagious abortion between 1948 (the year when the present law for combating the disease came into force) and 1954.

Reckoned in English pounds the total outlay during those seven years would run to some £569,940. Of this amount £1,000 has been used for propaganda; roughly £6,440 for laboratory tests of bulls used for artificial insemination; some £337,700 for diagnostic examinations; and approximately £224,800 for diagnostic examinations and for compensation paid for killing off reactors belonging to dairy member-groups which had voted for eradication within a fixed time-limit.

In addition, from the aforementioned fund which was raised by taxing certain exports, an amount of some £861,815 has been paid for killing off reactors. The fund has also paid some £165,000 for diagnostic examinations.

However, until now the expenses incurred by the Treasury and by the fund for the campaign have totalled together not more than 1.6 million pounds—an amount which should seem by no means excessive when we consider what has been won by the campaign during the period that has elapsed since its initiation.

Brucellosis Control and Eradication in Canada

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FIRST, I desire to express thanks to the British Veterinary Association for inviting a Canadian to present a paper at its annual meeting. The subject which you have chosen is of general interest in many parts of the world. I hasten to add, however, that Canadians have little or no first-hand knowledge on the problem of eradication on a national scale since we have barely arrived at a point where a semblance of control of brucellosis has been gained. We are hopeful that operations aimed at eradication will commence in the not too distant future.

It is not the intention to present a documented scientific thesis, quoting pertinent literature, since this would use up the time of the meeting and perhaps serve no useful purpose. The aim will be to present a simple story relating the efforts made in Canada, particularly the investigational background, the reasons for some of the steps taken, and the local conditions that in part dictate our approach.

It is obvious that what applies to Canadian conditions may have little or no application in Great Britain. Therefore it is necessary to point out a few salient facts that in some measure govern our activities.

That Canada is adjacent to the United States, whose large population demands an ever-increasing amount of live stock and live stock products, has led to the development of a voluminous export trade which, in large measure, is a one-way traffic. Certain sections of the Canadian live stock industry have come to depend to a very considerable extent on this trade. Therefore, conditions which obtain in the United States or which are imposed in the United States must govern to some extent our approach to a subject of this kind. In a word, there is sometimes indirectly imposed on Canadians a requirement which may not always conform to their scientific thinking.

Another factor is that Canada, unlike the United Kingdom, is composed of a number of provinces united under one central government. This government has authority over importations, matters relating to export, the spreading infections within the country and that which, broadly speaking, affects the animal health of the nation. The provinces, nevertheless, do play a prominent part in the control of diseases that are not of a pestilent nature. It follows, therefore, in some infectious processes, such as brucellosis, that both the central and provincial authorities play a part. This is generally done through a co-operative programme.

Perhaps one factor might be mentioned, namely, that we have two veterinary organisations connected with the Canadian Government — the Health of Animals Division that attends to regullatory work, and the Animal Pathology Division whose duty it is to engage in research and laboratory services. While these two Divisions are distinct, they operate with excellent co-operation under one sub-department of government. The result is that in general the scientific aspects of a problem receive consideration by the latter Division and if brought to a satisfactory working operation are applied on a broad scale by the former Division.

History of Brucellosis Work in Canada

In 1914, officers of the Canadian Government became mildly interested in the problem of brucellosis. For several years no sustained research was carried on and only a few feeble and fitful attempts were made to test methods of diagnosis and to use the live vaccine which had been developed by Sir John M'Fadyean in Great Britain. In 1923, however, a more active programme was established with objectives more sharply defined. It was at once apparent that in spite of the voluminous literature on the subject that there was still a dearth of pertinent information on which to base control measures. Serological methods, more particularly their interpretation, were open to criticism. In addition, the public was poorly informed about known facts concerning the disease. Moreover, the feeling had grown and indeed was fostered by the unfortunate name of the disease, "Contagious Abortion," that abortion was a constant symptom of infection. In a word, the public of our country was not conditioned to use the sparse information available and our veterinary officers had much to determine before active methods could be adopted.

It seemed to us in those days that the first requirement was to study intensively serological methods of diagnosis; then, having fixed on a method or combination of methods which appeared satisfactory, to study for several years the sera of animals in infected herds, with the objective of determining the persistence of infection as indicated by serological tests, supplemented, when possible, by bacteriological methods. Obviously, this programme was a long-term approach and similar to that being carried out in other progressive countries.

The Experimental Farms system which had been developed in our country possessed 24 farms, situated in every part of the country. Each of these had a herd. Later events indicated that only six were free from brucellosis. To com-

mence with, the large Central Farm was taken on as an experimental unit and serological examinations and bacteriological culture work carried on for several years. Data were correlated with the breeding records and other available information. No purpose would be served in going into details and it is sufficient to say that confirming the work of others or information gained first-hand led to the following:—

(1) Abortion is a very inconstant symptom, with a high incidence only during "storms".
(2) The majority of cows which abort do so once or twice.
(3) Infection as evidenced by a positive serological reaction is chronic and in the majority of instances lasts for the life of the animal.
(4) The agglutination and complement fixation tests are satisfactory methods of diagnosis. There is an advantage in using both methods for experimental study.
(5) The titre of antibody gives no indication of the likelihood of the occurrence of abortion.
(6) The serum titre of some animals fluctuates, particularly those of a low order, resulting in a classification of positive, a few months later negative, only to return to positive at a later date. This must be taken into consideration in spacing tests for control purposes.
(7) Infection of one or more quarters of the mammary gland occurs frequently. This is exceedingly persistent and organisms are eliminated continuously during the lactation period.
(8) Antibody is contained in the milk when the mammary gland is infected.
(9) New-born calves may be passively sensitised by drinking milk containing antibody.
(10) Organisms are excreted from the uterus of an aborting cow for a short time before and about three weeks after parturition.
(11) Only a small number of infected animals going full time excrete the causative organism from the uterus.
(12) In general, calves are insusceptible to permanent infection.

Methods

On the basis of the points mentioned, two alternative methods were arranged, to be used in accordance with the incidence of infection in a herd:—

(a) Serological examination of all the members of the herd every three months, with the removal and slaughter of infected animals; this to be applied when the incidence of infection was low.
(b) Serological examination of all members of the herd every three months, with the removal of infected animals to separate quarters. When calves were born, these to be removed immediately to a neutral area. All milk from the infected unit to be pasteurised and manure removed to an area to which non-infected animals and calves had no access. This system was applicable when the incidence of infection was high.

A serological examination of all animals on the 24 farms forming the Experimental Farms System determined that 18 of these were infected and of these four had 10 per cent. or more reactors. These four farms were dealt with by the latter plan mentioned while the others were managed by the former.

In two years, 10 farms were free of infection and in three years all farms were free. As time went on, events showed that there was a tendency to become careless after a period of freedom from disease with the result that several of the farms had minor outbreaks which had to be dealt with in an appropriate way.

It is evident that a system successful with herds on government farms may be inefficient in ordinary commercial herds. In the former, special means of isolation are available, control of personnel can be arranged, and the factor of profit is not important. Therefore, the only effective test of control measures was to make them available on a voluntary basis to commercial herd owners.

Our experience did direct attention to one important factor, namely, the difficulty of protecting individual farms. This brought us early to the conclusion that when the appropriate time arrived to introduce a vigorous elimination plan this should be done on an area basis, permitting the control of infected animals coming into or leaving areas containing many herds. By this means, individual farmers may operate within protected lines.

Official action

It was felt that the experience gained was sufficient to recommend an official attack on the problem. The result was that in 1929, the Health of Animals Branch introduced a bovine infectious abortion herd plan. This, with modifications from time to time, has been in operation since.

The first extensive testing indicated that about 20 per cent. of the herds were infected. After the introduction of the plan, however, the number of herds in which infection was found was relatively small, the reason being that the "plate" method had been developed to a point where private practitioners could employ it and thus remove from the herd infected animals, after which steps were taken to enter the plan. This, of course, precluded obtaining accurate figures, based on a large number of herds, of the incidence of infection in the country.

Meanwhile, an intensive programme of study had been pursued by the United States Bureau of Animal Industry. This was aimed, principally, at producing an agent capable of stimulating resistance in susceptible animals. Like us, they had come to the conclusion that injecting live *Brucella abortus* into normal adult cattle was a bad

practice and rendered satisfactory serological examination impossible. They had, however, conceived the idea of sorting out a suitable strain possessing mildly invasive properties and in addition inoculating this into calves, which are, in large measure, refractory to permanent infection, rather than into adult animals. The papers published by Buck (1930) and Cotton, Buck & Smith (1934) were to have a profound effect on our outlook and whole approach to the problem.

May I, without impropriety, insert a personal note? As a young man I had come to know W. E. Cotton. No investigator has impressed me more than this kindly, earnest and critical scientist. He apparently had no ambition for fame and was the finest of colleagues, both to persons of his own age and to juniors. When his name became associated with calfhood vaccination it was felt by the author that the approach must be sound. I had frequent consultations with Dr. Cotton, both personal and by correspondence. This resulted in a modest amount of investigational work being attempted in Canada. The American findings were verified and a few other factors brought to light. Without going into tedious details these may be summarised as follows:—

(a) Strain 19 possesses little invasive properties but stimulates a considerable degree of resistance against *Br. abortus* infection. It does not produce a solid immunity.
(b) The age at which a calf is inoculated is important from the standpoint of stimulating resistance and escaping prolonged production of agglutinins which complicate the serological examination of herds.
(c) Calves that fail to produce humeral antibodies are not resistant.
(d) Care must be taken in handling the vaccine to guard against loss of viability. Age, incorrect temperature of storage, and agitation are all factors in reducing the number of viable organisms. This may reach a level which is insufficient for the stimulation of resistance.

Soon after 1940, the use of Strain 19 on a small scale commenced in Canada. However, provincial programmes were developed and these in general were based on vaccination. This encouragement led to the wider use of the vaccine until it now forms an important factor in the control of brucellosis. At the commencement, inadequately informed persons frequently led live-stock men to believe that the total elimination of Brucella infection by vaccination was only a matter of time. As work progressed, a more conservative attitude was adopted and now it is realised that Strain 19 can temper and minimise the economic loss but cannot be expected totally to eliminate the disease. If the incidence is reduced to a minimum then the application of a forceful elimination programme on a large scale becomes possible.

Those who have had experience in this field will realise that any elimination programme must be based on the application of serological methods, which involves a tremendous amount of work both on the part of field officers and laboratory workers. If a satisfactory method were at hand which would determine herds free from infection it would go a long way towards making an elimination plan more practical. Obviously, the work of a more or less fixed personnel could be spread over a greater area. We had visions of the ring test answering this purpose. Experience, however, has not indicated that the ring test in our hands is sufficiently free from non-specific interference to play an important part in an elimination programme. For this reason, considerable time is being spent in attempting to design a more delicate and specific serological method for the examination of pooled milk samples.

What was surmised early in the work which has been reviewed seems to be verified by broader experience. If brucellosis is to be eliminated the attack must be made on a broad scale and on an area basis. The reduction of the incidence of infection by the various co-operative programmes carried on by the Dominion and Provincial Governments and in which vaccination plays a prominent part has in addition to minimising the task produced official machinery for a widespread attack on the problem. In the opinion of the author, elimination on a national scale will have to be organised on an area basis so that herds found clean and herds from which all infected animals have been removed will (to use a military term) be able to say "We stand within the lines of Torres Vedros".

Summary

The investigational work and early trials in Canada which led to attempts to control brucellosis are described.

The results of the application on Government-owned herds of the principles involved were encouraging and led to the introduction of plans for the control of brucellosis on a wider scale.

That both the Dominion and Provincial Departments became involved has been mentioned.

Approaching the subject of eradication of brucellosis, it is the author's view that this can be done efficiently in Canada if carried out on an area basis.

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Brucellosis Control and Eradication in the U.S.A.

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IT is a pleasure for me to come again to Great Britain and renew some of the friendships established on previous visits. And I am especially happy to participate in a meeting of the British Veterinary Association. As some of you know, I was privileged to spend about six months in your country in 1942. During that time I formed a great admiration for the veterinary profession in the United Kingdom and I am honoured by your kind invitation to meet with this Association.

For a long time I have been closely associated with various aspects of the brucellosis eradication campaign in the United States and naturally feel a strong interest in the subject. Moreover, since 1942, I have had more than a passing interest in your brucellosis problem. I am particularly anxious to learn what has been accomplished here during the past 12 or 13 years by the brucellosis vaccination scheme.

Whether we like it or not, all of us must accept the fact that we are living in an era of inter-continental travel which, in effect, shrinks the globe more and more each year. For example, in about 14 hours after leaving New York, I was in London. Travel between our two countries is, of course, only a small fraction of the vast network of rapid transportation systems that reach into all countries of the world. While these advancements are beneficial, they bring into focus certain problems that heretofore did not exist or were of negligible importance. The problem with which we as veterinarians are concerned relates to the increased potential of new diseases being introduced among our domestic livestock. This is not something merely for consideration: the danger is a present one and promises to become increasingly serious. Thus, close international co-operation by livestock sanitarians is an absolute necessity. A case in point is the valuable scientific assistance we received from Great Britain and other European countries in combating foot-and-mouth disease in Mexico. Considering our lack of experience with this disease, since 1929, it is hard to say what the outcome of that campaign might have been without such co-operation.

We in the United States hold the view that many disease problems are either common to most other countries or are a direct threat to those in which they have not yet been identified. Hence, mutual benefits can be derived by pooling our efforts. Because we have no language barriers to contend with, there is more reason than ever for working relationships to be extremely close between Britain and the United States.

With respect to brucellosis, most of us know that, beginning with the renowned work of Bruce on the island of Malta, interest in brucellosis has spread throughout the world. Related studies have shown the infection to exist in practically all countries where susceptible livestock are raised. During the past half century, research in these countries has been directed mainly toward the development of methods for the control and eradication of brucellosis in animals. The fact that *Brucella abortus*-infected cattle are found in most parts of the world probably explains the more extensive data collected on bovine brucellosis as compared with brucellosis of swine and goats. The volume of information available on brucellosis is relatively large and compares favourably with that assembled during any similar period for other infectious diseases. Interestingly enough, the validity of early research findings has held up extremely well over the years. Much of it is just as appropriate to-day as when it was first revealed. There is no question but that veterinary research on brucellosis has been outstanding over the years and has far surpassed investigations dealing with human aspects of the disease. Accumulated information assembled from research findings and field experience throughout the world has made possible the concerted effort now being made to eradicate bovine brucellosis in the United States.

Brucellosis in the U.S.A.

Brucella abortus *Infection*

Although the first confirmed evidence of bovine brucellosis in the United States dates back to 1910, it was not until 1934 that organised efforts were undertaken to control and eradicate this disease, and sufficient testing was carried out to provide a basis for estimating the extent of infection. Of the 3.3 million cattle tested during the first year of this programme, 11.5 per cent. were classed as reactors. This compares with a maximum of around 5 per cent. animal infection for the country as a whole in the case of bovine tuberculosis.

For the past several years, brucellosis in cattle has been recognised as one of the most serious and widespread infectious diseases occurring among livestock in the United States. While the disease is most prevalent in the predominantly dairy sections of the country, it exists from coast to coast and from northern border to southern border. Even though the incidence of brucellosis in strictly range cattle is comparatively low, the infection frequently assumes serious proportions in feed lots.

Brucella suis *Infection*

Brucellosis was first identified in the United States as an infection of swine in December, 1914. However, there is reason to believe that *Brucella suis* was present in the country long before that date. Inasmuch as no nation-wide programme for the eradication of this disease has yet been put into operation, the incidence of brucellosis in swine cannot be accurately estimated. Limited records available on individual herd testing conducted in some

States of the Middle West have indicated an animal infection rate of between 3 and 5 per cent. for that area.

While the serious nature of swine brucellosis is well recognised by farmers, veterinarians, and public health officials in those sections of the country that are affected, it is less important to the country as a whole than bovine brucellosis. It is entirely possible, of course, that with the advancement of the eradication programme in cattle, a similar project may be required for swine.

Brucella melitensis *Infection*

The initial identification of caprine brucellosis in the United States was made in 1911 in the state of Texas. As in the case of swine brucellosis, the information on the extent of Brucella infection in goats is inadequate at the present time. As might be expected, this disease appears to be confined largely to the South-western States where most of the goat population in the United States is found. Based upon the results of scattered testing conducted in various sections of the United States, it would appear that the incidence of *Brucella melitensis* infection in goats does not exceed 2 per cent.

Bovine Brucellosis Control and Eradication Procedures

Test and Elimination of Reactors

The nation-wide campaign to eradicate brucellosis from cattle in the United States was inaugurated in the summer of 1934. In the beginning, this programme was developed as a co-operative State-Federal undertaking in which eradication was based entirely upon the elimination of reactors to the blood serum agglutination test. At that time, there was considerable hope that this disease might be combated in the same manner as bovine tuberculosis, and with equal success.

Although a great deal was accomplished during the early years of the project by the test-and-slaughter method, it soon became apparent that complete eradication by this procedure alone would be very difficult to accomplish on a nation-wide scale. Increasing evidence developed to show that, because of inherent differences in the epizootiology of bovine brucellosis and tuberculosis, each would require somewhat different methods for control and eradication. Regardless of the procedures employed, it has been repeatedly demonstrated that the progress made in various areas of the country is far more closely related to the thoroughness with which procedures have been applied than with actual methods themselves. In other words, while there is a need for employing available methods under conditions best suited to their usefulness, it is likewise important that they be applied in a thorough and aggressive manner.

Variations in the types of herds infected with brucellosis, differences in the character of the disease as it affects various herds, and the degree and length of time infection has been present are important factors to be considered in the selection and application of appropriate means of control. The complex nature of this disease cannot be ignored if maximum results from any plan are to be achieved. The value of test and slaughter has been convincingly demonstrated when used under suitable conditions. However, one of the greatest dangers connected with such a programme is the matter of replacements. Herds in which heavy losses have been sustained through rigid testing programmes must depend largely upon outside sources for the animals necessary to maintain commercially active enterprises. The owners of such herds are extremely vulnerable from at least two directions. First, they face the danger of introducing infection through newly purchased stock, even when the best precautions are exercised. Secondly, the introduction of known healthy animals from herds that have been free of the disease for several years provides fertile ground for perpetuating any residual infection that might remain on the premises. The susceptibility of such animals to brucellosis is usually quite high.

In spite of a great deal of confusion and many false starts, approximately 33 million cattle were tested during the first five years of the programme and the percentage of reactors was reduced from 11.5 in 1935 to 2.5 in 1939. During this period much was learned about the real value and limitations of the test-and-slaughter method of eradication. It soon became evident, for example, that the results obtained by the elimination of reactor animals depend largely upon the stage of infection existing in a given herd at the time eradication efforts are undertaken. In cases where the disease has been introduced recently and is accompanied by frequent abortions, there is far less chance of immediate success than is possible with herds that have passed through these violent early stages of infection. Therefore, the most favourable time to eradicate brucellosis from herds appears to be after clinical manifestations have subsided. This, of course, is impossible in programme operations and adds to the problems of combating this disease by the elimination of reacting cattle.

Vaccination

Based upon the results of extensive laboratory and field investigations, Strain 19 vaccine was approved in 1941 for use in the co-operative State-Federal brucellosis eradication programme. Previous experiences with test and elimination of reactors already had emphasised the need for an immunological agent and the advent of Strain 19 was generally welcomed throughout the country. In fact, during the first few years after it became available, vaccination was employed more widely and indiscriminately than was justified. This was especially true with respect to its use in the vaccination of adult animals. The persistent vaccinal reactions resulting from over-age vaccinations have been a continuing source of confusion in herds where eradication measures, based upon the removal of reactors to the blood agglutination test, have been put into operation.

As might be expected, vaccination was extremely popular in many sections of the country and each

year since it became a part of the official programme there has been a marked increase in its use. For the five-year period extending from 1941 through 1945, approximately two million calves were vaccinated officially. With vaccine available through commercial channels, there was probably at least an equal number of vaccinations performed outside the co-operative programme during the same period.

As the use of vaccine increased, growing evidence was provided from the field that there were definite limitations to the protection afforded by vaccination with Strain 19. The immunity established through use of this product might be recognised as being relative and not absolute. This fact has been overlooked too often and explains some of the disastrous results that have been associated occasionally with vaccination. There is no question, of course, about the value of Strain 19 vaccine when it is used under conditions that assure maximum benefits. The importance of limiting exposures of vaccinated animals, through the adoption of approved animal husbandry and sanitary practices, has been proved in hundreds of cases.

Brucellosis ring testing

As a result of earlier studies carried out in Europe on the "ABR" test, co-operative investigations of this procedure were undertaken in the fall of 1947 at the University of Minnesota. Based upon consistently favourable reports covering the experimental use of the ring test, it was included, in 1952, as part of recommended procedures approved for use in the official brucellosis eradication programme. Since its adoption, the ring.test has proved extremely valuable, especially in predominantly dairy areas of the country. Through its use, large numbers of dairy-type herds can be screened rapidly and economically for presumptive evidence of Brucella infection. This makes possible a concentration of eradication efforts on herds that are probably infected. Where moderate to low degrees of infection exist, counties can be ring tested at approximately 10 per cent. of the cost of blood testing the same areas. Both milk and cream samples can be examined by this method. Because it is not effective for diagnosing individual animal infection, suspected herds must be routinely blood tested. In so far as its efficiency is concerned, it has been found that the ring test locates around 90 per cent. of the herds in which one or more Brucella-infected animals are in production. On the average, follow-up blood tests on ring-reacting herds are in agreement in 70 per cent. of the cases. Approximately 70 per cent. of the failures to agree are due to infected animals being out of production at the time ring tests are made. There seems to be a psychological aspect associated with milk testing that encourages livestock owners to become actively interested in eradicating brucellosis from their herds. This, together with other factors relating to the usefulness of the test, has resulted in its rapidly increasing use in various states since 1952.

Uniform Methods and Rules

Progress in the bovine brucellosis eradication efforts during the years before 1947 was greatly handicapped by lack of uniformity in operations in different parts of the country. Instead of following a similar eradication pattern, the states insisted upon developing their own programmes. Obviously, this lack of a uniform approach held little prospect for the eventual eradication of brucellosis.

In order to correct this situation, the Bureau of Animal Industry took steps to encourage the establishment of uniform control and eradication practices. Sufficient interest was stimulated through discussions with interested groups throughout the country to result in the preparation and adoption of uniform bovine brucellosis eradication procedures at the December, 1947, meeting of the United States Livestock Sanitary Association. With minor amendments made during subsequent years, this outline has continued to serve as an effective instrument in promoting the eradication project throughout the country. These recommendations are an integral part of the State-Federal memoranda of understanding relative to the co-operative brucellosis eradication project.

The design of these recommendations was predicated on the importance of providing reasonable flexibility for handling the brucellosis problem under varying herd conditions. Essentially they consist of four separate plans which may be reviewed briefly as follows:—

PLAN A—*Test-and-slaughter, with or without calf vaccination*

This plan has eradication as its immediate goal and is the method of choice where the incidence of infection is low and herds are self-contained. It has been highly successful in herds of this type when related recommendations have been closely followed. In the United States, about seven out of ten infected herds can be freed of brucellosis by two complete herd tests and prompt removal of reacting animals. Three herds in ten require three or more tests to accomplish the same results. Difficulties with this procedure are most frequently encountered in highly susceptible herds where virulent infection is spreading rapidly.

PLAN B—*Test, calf vaccination, temporary retention of reactors*

As the title indicates, this plan is designed to enable the owners of heavily infected herds to work out a difficult brucellosis situation in a gradual manner, thereby avoiding serious economic shock. This procedure permits reactors to be held in quarantined herds for periods not to exceed three years. Under normal conditions, this provides time to raise enough resistant heifers on the premises to allow replacement of the adult infected animals. Plan B has been widely used throughout the country and for the most part has worked effectively as a stepping stone towards Plan A and eventual eradication.

PLAN C—*Calf vaccination without test of any part of the herd*

This procedure was developed primarily to encourage the range cattle industry to recognise the brucellosis problem and to initiate some action directed towards its solution. It has been difficult to interest the range people in brucellosis eradication and Plan C was adopted as a means of bringing them into the programme with the hope that they would eventually move towards more effective participation. Plan C is confined to herds where the movement of animals is allowed only through special permits issued by state livestock sanitary officials.

PLAN D—*Adult vaccination*

Plan D was included in the procedures to counteract unofficial vaccination of adult cattle. Under present conditions, there is every reason to discourage this practice in the United States, and fortunately it has declined steadily during the past few years. In the presence of so-called "infection storms," a condition usually existing in herds where vaccination is requested, most of the susceptible animals already are infected before any value can be realised from the use of vaccine. Consequently, any benefits that may seem to be provided by adult vaccination are more imagined than real. Plan D requires the testing of entire herds, with vaccination of adults confined to non-reactor cattle that have been tested within the previous ten days. This plan is available for use only in emergencies where there is evidence of rapidly spreading infection and then only with written approval of the State-Federal co-operating agencies.

Brucellosis Eradication Procedures for Swine and Goats

At the present time no nation-wide programmes have been developed for the eradication of brucellosis from swine and goats. However, we may be approaching the point in the United States where such projects are essential. This is especially true with regard to swine brucellosis, which constitutes a recognised threat both economically and from the standpoint of public health.

Sufficient data have been assembled on brucellosis in swine during the past few years to permit the development of suggested methods for the control and eradication of this disease. The results of field trials based upon testing and segregation of weanling pigs have been encouraging and suggest the possibility that practical methods for economically eliminating *Brucella suis* infection from swine are now available. Although the blood-serum agglutination test does not possess the same accuracy in swine as in cattle, it has proved effective for diagnosing herd infection.

As already pointed out, *Brucella melitensis* infection in goats does not occur extensively in the United States and, consequently, no concerted effort has been made to eradicate the disease. However, from the results obtained by the removal of reactors to the blood-serum agglutination test in individual flocks throughout the country, it seems reasonable to believe that this procedure can be effectively employed as an eradication tool. It has been found that goats reacting in titres as low as 1 :25 must be considered infected if test and elimination of reactors is to be successful.

Bovine Brucellosis Eradication Progress in the United States

During the first 15 years of the co-operative eradication programme, progress was erratic in the 48 states, which cover a very large area, even though the overall picture continued to show general improvement. For many years the project was hindered by lack of unified effort. However, great improvement was noted following the adoption of uniform control and eradication practices. Further difficulties arose during World War II as the result of acute shortages of trained veterinary personnel available for field operations. Figures 1, 2 and 3 graphically illustrate the trend of eradication efforts and the intimate relationship between infection rates and the volume of testing performed.

From July, 1934, to June 30th, 1954, a total of nearly 11 million herds, representing approximately 127 million cattle, were tested for brucellosis. Over the same period, the indicated animal infection dropped from 11.5 per cent. to 2.6 per cent. This 2.6 per cent. animal infection rate represents evidence of the disease as found in 14.2 per cent. of the herds tested. As mentioned before, the eradication picture has changed rather markedly at various times, concurrently with alterations in the level of field activities. During the first seven years of the programme, when yearly testing volumes remained high, there was a decline each year in the percentage of reactors disclosed. With personnel problems developing in 1942, testing began to drop off and the percentage of reactors started to rise, reaching a secondary peak of 5 per cent. in 1947. From this point on, there has again been a consistent reduction in animal infection rates, which were down to 2.6 per cent. at the end of the fiscal year 1954.

Over the past few years, greatly increased interest in brucellosis eradication has been displayed by various groups, including the livestock industry, the veterinary profession, livestock sanitary officials, and the general public. This interest has been reflected in the growing volume of official work performed. For the 12-month period ending June 30th, 1954, more than nine million cattle were tested for brucellosis in the United States. This represents an increase of 12 per cent. over the number of tests made in 1953 and exceeds, by nearly a million, the previous high reported in 1935. During the 14-year period (1941-54) a total of 21.3 million calves were officially vaccinated with Strain 19. Since its approval in 1941, the use of Strain 19 has increased each year, reaching an all-time high of nearly four million calves vaccinated in 1954.

While it is impossible to assess accurately the value derived from vaccination over the past several years, there is reason to believe it has played an important rôle in the eradication project. As pro-

grammes based upon test and elimination of reactors move into areas where widespread vaccination has been conducted, the incidence of infection disclosed has been surprisingly low in many instances. It has been encouraging to note a gradually changing attitude on the part of livestock owners with respect to the rôle calf vaccination should play in the eradication plan. Rather than accepting this procedure as a means of control alone, there is increasing interest in utilising vaccination as a move towards eventual eradication. In many sections of the country where vaccine has been extensively used, we are seeing a significant up-swing in the volume of blood testing. There is no question about the advantages of vaccination when it is employed as an adjunct to test and elimination of reactors.

So far, three of the 48 states have qualified as Modified-Certified Brucellosis-free Areas. This designation certifies that the herd and animal infection disclosed in these states by testing does not exceed 5 per cent. and 1 per cent. respectively. A number of other states are rapidly approaching this same status and should be eligible for certification within the near future.

Owing to extensive movements of livestock, the maintenance of certified areas has constituted a rather serious problem. Previous experience with recertification at three-year intervals has shown that a significant increase of infection may be found in many such areas over this period of time. With the advent of the milk and cream ring test, this difficulty has been largely overcome in dairy sections of the country. By conducting semi-annual ring tests at milk and cream collecting stations, it is possible to detect most centres of infection early enough to limit spread of the disease. From the standpoint of its economy of operation and its ability to detect brucellosis on a herd-infection basis, the ring test has fulfilled most earlier expectations. This test offers a means of employing qualified lay technicians for the collection of milk and cream samples, thereby permitting the concentration of veterinary services on herds presumed to be infected.

Since it became a part of the official programme in 1952, approximately two million herds, representing an estimated 37 million cattle, have been ring tested in 29 states. This compares with almost the same number of herds officially blood tested over the same period in 47 states and underlines the savings in both money and time that can be made through use of this screening device.

Brucellosis Test Data on Swine and Goats

The increasing recognition that must be given to inter-species transmission of Brucella types has made it essential that some consideration be given to other susceptible livestock groups in the United States. With this in mind, we have been tabulating results obtained from tests made in the various states. To date, these records have been collected over a period of three years and represent a total of 221,000 swine and 271,000 goats tested for brucellosis during that time. Of the swine tested, 5.7 per cent. were classed either as reactors or suspects. In the case of goats, 1.8 per cent. were similarly identified. With no organised programme available for the eradication of brucellosis from these species, the number of tests being conducted at owners' requests continues to be surprisingly high. This study reflects growing concern about the brucellosis situation on the part of swine and goat raisers.

Expansion of the Bovine Brucellosis Eradication Programme

The Congress of the United States has made available additional funds for use in accelerating the brucellosis eradication project during the fiscal years 1955 and 1956. This action could not have been taken at a more appropriate time, as current interest in eradicating the disease has never been greater. As might be expected, immediate expansion of these operations has been greatest in the states where local programmes were best organised. However, it has been possible to accelerate the programme in most sections of the country far more rapidly than was expected. The fact that the expanded programme called for the restoration of former maximum indemnity payments of 25 dollars for grade animals and 50 dollars for pure-breds to owners of cattle destroyed because of brucellosis has no doubt been an important factor in this regard. Federal indemnity payments may not exceed one-third of the difference between the appraised and salvage values. Under present operating procedures, states with co-operative agreements are no longer required to match Federal indemnity payments. However, as of June 30th, 1955, 23 states and the Commonwealth of Puerto Rico were participating in the payment of indemnity.

Fortuitously for the expanded programme, two years of research by Agricultural Research Service scientists was completed in time, a few months ago, to throw new light on the interpretation of reactions in officially calf-vaccinated animals. These studies, conducted in field-vaccinated herds in different parts of the country, were designed to correlate blood-serum agglutination titres in official vaccinates and non-vaccinates with results of bacteriological examinations.

Briefly, these investigations showed that, in the case of calf-vaccinated cattle, the diagnostic level used for interpreting blood-serum agglutination reactions could be safely raised one full dilution over that employed for routine diagnosis of brucellosis in unvaccinated animals. Based upon American standards, this means that, with the alternate interpretation, officially vaccinated animals are not considered infected unless they react to the agglutination test in titres of 1 :200 or higher. This compares with reactions in the 1 :100 or higher dilutions that are still considered diagnostically positive for non-vaccinates. The new interpretation for vaccinates has been accepted and incorporated into the official recommendations covering procedures for eradicating brucellosis from cattle.

At the inception of the expanded programme, it was realised that the personnel requirements for the various states would have to be met through the

employment of practising veterinarians. This being the case, a system was developed to pay co-operating veterinarians on a per-head or per-herd-and-per-head basis, on schedules approved by the Agricultural Research Service and the individual states. Participation of the veterinary profession in the new programme has been excellent. Approximately 5,000 are now signed up for service and the majority are actively engaged in various aspects of the programme.

Table I shows the volume of brucellosis eradication activities for the two nine-month periods ending June 1st, 1954, and June 1st, 1955, respectively.

TABLE 1

Comparison of brucellosis activities in the United States, September, 1953—May, 1954, before the expanded programme began, and September, 1954—May, 1955, after the inauguration of the expanded programme

Activities	September, 1953, to May, 1954	September, 1954, to May, 1955	Per cent. of Change
Blood tests:	587,252	753,492	28
Herds	7,799,897	11,346,656	45
Cattle			
Ring tests:	790,124	847,667	7
Herds	14,011,087	14,333,034	0.2
Cattle			
Vaccinations	3,575,784	3,613,718	1.0
Herds under supervision	2,286,406	2,554,224	12
Reactors slaughtered	104,066	213,942	106

Based upon results covering the first nine months of the expanded programme it would appear that operations for 1956 may be expected to approach a 12-month level of 22 million blood tests, 5.5 million vaccinations, and 400,000 reactors slaughtered. If this forecast proves reasonably accurate, there is reason to believe additional states will be certified by June 30th, 1956, and sufficient momentum generated to assure continued progress after that date in other sections of the country.

Discussion

As might be expected with any undertaking of similar magnitude, the brucellosis eradication campaign in the United States has encountered its full share of obstacles. In the beginning there was considerable apathy on the part of large sections of the livestock industry towards eradication efforts. Much of this was eventually overcome through intensive educational work conducted through such agencies as State and Federal Extension Services, the National Brucellosis Committee, the American Veterinary Medical Association, the National Research Council, the U.S. Livestock Sanitary Association, and public health groups. All available channels for disseminating information have been utilised, including the press, radio, television, bulletins, leaflets, fact sheets, speeches, and educational films. Experience, sometimes gained the hard way, has shown that the co-operation received from livestock owners in this or any similar project is directly related to the effectiveness with which they have been informed about the nature and value of the contemplated programmes. Brucellosis eradication progress has been most rapid in areas where education has been handled best.

When the economic and public health advantages of this project are thoroughly understood, livestock owners usually assume leadership in promoting the work. In most of the states where the programme is most active, much of the educational work has been handled through state and county brucellosis committees. These committees are composed of representatives from breed associations, agricultural groups, the veterinary profession, extension services, public health agencies, and other interested organisations. At least 33 states now have such committees functioning on an active basis. All aspects of brucellosis are covered in the educational campaigns. For example, emphasis is again being placed this year on the economic benefits already derived from eradication efforts and the additional savings that may be anticipated with advancement of the programme. In this connection, it has been pointed out that in 1947, when the incidence of bovine brucellosis was 5 per cent., annual losses in milk, calves, and other effects of brucellosis amounted to an estimated 92 million dollars. After the national incidence was cut to 2.5 per cent. in March, 1955, estimated annual losses had declined to approximately 46 million dollars. On that basis, it was explained that with each 0.5 per cent. reduction in the nation-wide incidence of brucellosis, the annual financial loss caused by this disease would be lowered by an additional nine million dollars. Thus, the financial savings realised each year from progress already made in eradicating bovine brucellosis is considerably more than the combined State-Federal expenditures used to combat the disease.

Early in the programme some criticism developed with respect to the accuracy of the blood-serum agglutination test employed for diagnosing Brucella infections. Inasmuch as antigens were being produced at that time by a number of different laboratories, there is reason to believe some of these accusations were justified. Disagreements between different laboratories were not unusual and resulted in a gradual loss of confidence in the test. This dissatisfaction increased to the point where finally the U.S. Livestock Sanitary Association requested the Bureau of Animal Industry to undertake the development and distribution of a standard Brucella antigen. As a result of this action, all Brucella antigens used in the State-Federal co-operative testing laboratories have been produced by the Department of Agriculture since 1940. This standardisation of antigens, together with the application of uniform techniques, has improved testing operations throughout the country to such a degree that the diagnosis of brucellosis in cattle is now seldom questioned. Present efficiency levels are maintained by routine check testing conducted in all official laboratories at regular intervals. Over the past seven years, approximately 91 per cent. of both the tube and plate tests run at these laboratories on a check-test basis have agreed with Federal interpretations established at the Animal Disease Station, Beltsville, Maryland. These experiences have emphasised the importance of establishing and maintaining confidence in the diagnostic procedures employed as part of the eradication project.

There have been several occasions when the eradication programme was plagued by shortages of veterinary personnel available to meet service requirements. As already explained, these periods are clearly reflected in annual testing records by a corresponding resurgence of indicated infection rates. These unpredictable personnel shortages have continued to handicap field operations to the extent that, with inauguration of the accelerated programme, it was considered impractical to try to operate with full-time regulatory veterinarians. Instead, arrangements were made to employ practitioners on a fee basis rather than on a *per diem* basis for work performed in local areas. This enables them to make better use of their time. With approximately one-third of the active profession now participating in the programme, this system has proved more workable than expected. Without this splendid co-operation on the part of the profession, it would be impossible to meet service requirements.

Early in the programme, widely divergent views were held by various groups throughout the United States on the best procedures to follow in attempting to eradicate bovine brucellosis. Consequently, there were serious variations in the methods employed by different states. This division of thought, which seriously handicapped the national eradication programme, continued until 1947 when general agreement among the states was reached on "Uniform Methods and Rules for the Establishment and Maintenance of Certified Brucellosis-Free Herds of Cattle and Modified Certified Areas." Since that time, the programme has moved forward in an orderly fashion.

After Strain 19 vaccination of calves became official, most of the objections to Strain 19 vaccination resulted from persistent vaccinal reactions or temporary titre flare-ups in vaccinates. Reactions of this nature, while not too frequently encountered in properly vaccinated animals, are always a disturbing element and seriously interfere with efforts to determine the exact brucellosis status of herds in which they occur. Vaccinates showing these low, fluctuating blood-serum agglutination titres have been a real problem with respect to conformance with milk ordinance requirements and inter-state regulations.

The new interpretation of tests for calf-vaccinated cattle should help to overcome some of the objections to vaccination. Already, in the United States, this move has been influential in stimulating increased interest in official vaccination and promises to promote the intelligent use of vaccine without endangering the programme. Predictions have been made that it will remove thousands of animals from the area of suspicion and save them from condemnation as reactors, enable farmers to learn more quickly the brucellosis status of their animals, make dairy herds qualify more readily under present and proposed milk ordinances, and reduce the manpower engaged in brucellosis eradication because fewer men will be required to keep fewer suspected animals under observation.

Although controlled vaccination is extremely helpful, the indiscriminate use of vaccine as a means of living with brucellosis is a false concept of disease control and will only prolong the time until eventual eradication can be achieved. There is no easy solution to the brucellosis problem and vaccination is not the panacea some have believed it to be. However, as an adjunct to other essential elements of brucellosis control and eradication, it can play an important part.

While it is possible to conduct brucellosis eradication on an individual herd basis, frequent difficulties are encountered in maintaining such herds free of the disease, especially when they are located in heavily infected areas. For this reason every effort is being made to expand the present co-operative programme on an area basis. Counties usually constitute the political sub-divisions of a state that are designated as areas for eradication purposes. As they are freed of infection, counties are individually certified until such time as the entire state becomes qualified. Moreover, as has been true with most other programmes of this nature, maximum progress cannot be expected when owners are required to pay the expense of servicing their own herds. There will always be enough people who are only mildly interested in the scheme to endanger the efforts of others. Transmission of this disease from herd to herd is relatively simple and reservoirs of infection cannot be effectively isolated in a country as large as the United States. With this in mind, co-operative brucellosis eradication work requires that service be available to owners without cost.

In the case of bovine tuberculosis, eradication efforts were definitely affected by public health influences. The same thing is developing rapidly in the United States with respect to Brucella infection in cattle. A leading step in this direction was taken in 1953 when the United States Public Health Milk Ordinance and Code, a document recommended for adoption in the various civil divisions, was altered to require that within a specified period not to exceed three years after adoption of the ordinance, all milk and milk products for pasteurisation shall be from herds certified by State livestock sanitary authorities as following either Plan A or Plan B, approved by the U.S. Department of Agriculture for the eradication of brucellosis. This provision supplements existing recommendations dealing with milk and milk products for raw consumption, which must be produced by brucellosis-free herds.

An increasing number of states and cities throughout the country are adopting either this code in its entirety or similar ones having comparable objectives. As might be expected, these ordinances are having a salutary effect in the milksheds involved and have been instrumental in stimulating increased eradication efforts. In their publicity campaigns, public health agencies have repeatedly called attention to the fact that complete control and eradication of brucellosis in man cannot be accomplished until the primary sources of infection, diseased animals, are eliminated. It is a convincing argument and carries a strong appeal for support of brucellosis eradication.

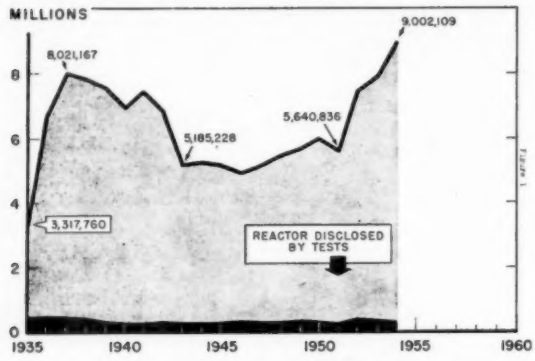

FIG. 1.—Official Blood Serum Agglutination Tests

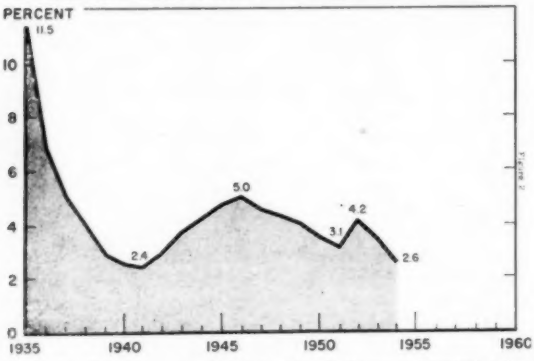

FIG. 2.—Reactors to Official Blood Serum Agglutination Tests.

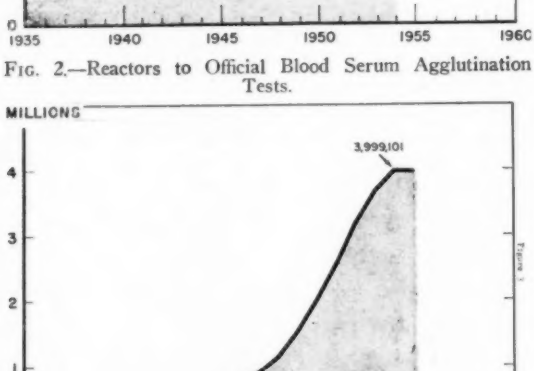

FIG. 3.—Official Calf Vaccination.

The chapters so far completed in the story of brucellosis eradication in the United States have covered a broad range of episodes, some of which have come close to being tragic. There were many mistakes and frustrations during the early stages of the programme. We like to believe, however, that we have learned from these mistakes and that they have helped us to develop more efficient procedures and operations.

From our long experience with the tuberculosis eradication programme, we realise that certain pitfalls lie ahead. For example, when tuberculosis was reduced to the point where the entire country became Modified Accredited Tuberculosis-free, the false impression developed that the eradication job was completed. We are still faced with this problem of public complacency, and it has hindered final tuberculosis eradication efforts. As the brucellosis campaign progresses, the same loss of interest may be expected to occur and we must be prepared in advance to meet it more effectively.

The task of eradicating brucellosis in the United States presents a serious challenge, but we are convinced that with intelligent and energetic promotion this project can and will be carried to a successful conclusion.

Summary

1. Although significant progress has been made in the campaign to eradicate bovine brucellosis in the United States, this disease still constitutes a serious threat to the livestock industry throughout the country.

2. Since 1934, when the co-operative State-Federal programme was initiated, the apparent incidence of brucellosis in cattle has been reduced from 11.5 per cent. to 5 per cent.

3. The adoption of Uniform Methods and Rules in 1947 was instrumental in eliminating confusion with respect to perferred control and eradication measures and has contributed much to the advances made since that time. These procedures are discussed in considerable detail.

4. The milk and cream ring test is filling a long-felt need for an effective means of economically screening large numbers of herds for evidence of Brucella infection. This procedure is making it possible to maintain the status of certified areas in dairy sections with a minimum of effort.

5. Based upon the results of limited surveys conducted in the United States, the incidence of *Brucella suis* and *Brucella melitensis* infections is estimated at 3 to 5 per cent. and 2 per cent. respectively.

6. No nation-wide programmes have been developed for the eradication of brucellosis in swine and goats. However, there is general agreement that with slight modifications, available methods can be used effectively to combat these infections as they exist in the United States.

7. The effect of increased financial support on the brucellosis eradication campaign is described for the first nine months of the accelerated programme.

8. The public health aspects of brucellosis are playing an increasingly important rôle in the eradication of brucellosis from all susceptible livestock species in the United States.

9. The various problems which have arisen in connection with the brucellosis eradication campaign are discussed, together with methods employed for their solution.

10. The present accelerated programme has demonstrated beyond question the widespread interest on the part of all groups concerned to eliminate completely the economic and public health hazards of brucellosis. There is convincing evidence that the proper application of available procedures can insure continued progress toward the goal of complete control and eventual eradication of all Brucella infections.

THE SPEAKERS' INTRODUCTIONS

The Chairman, Mr. E. Wilkinson, said that he wished to say "welcome to all" at the first meeting of the Congress at which papers were to be discussed. There was a most important subject before them, indeed a subject of world-wide importance, particularly with regard to food production. The essayists were from both the Old and the New Worlds and, of course, were all accepted authorities on the subject. Unfortunately, Dr. Mitchell, of Canada, was unable to be with them. No doubt many members would wish to speak, and it would therefore be helpful if speakers would bear in mind the relatively short time at their disposal. Director Nielsen would set the ball rolling by introducing his paper.

Director Woldike Nielsen (Denmark):—

As you probably know, veterinary surgeons in the five Nordic countries assemble every three or four years in one of our Scandinavian capitals to discuss veterinary problems of topical interest. Our last meeting was held in Oslo in 1954 and, for the first time, we did not discuss either bovine tuberculosis or contagious abortion—two afflictions which had otherwise always appeared on the agenda of former meetings.

In other words, veterinary surgeons in Nordic countries no longer consider the eradication of these two chronic bovine afflictions a major veterinary problem; and, if farmers, their organisations, or the central administration in one or another country still hesitate to institute a systematic campaign against these illnesses, we consider ourselves justified in letting them know that we are ready to do so at once.

In my printed paper I began by mentioning the assistance given by the Crown in the form of legal enactments supporting our work in combating contagious abortion. I then went on to enumerate the various regulations set by the veterinary directorate to be followed whenever a campaign against this illness was to be arranged in an infected herd.

These regulations are based upon the following facts:

1. In the milk ring test we have an excellent diagnostic test to indicate which herds are infected, or to control their freedom therefrom. But from the results we have obtained we would not recommend its employment as an individual test.

2. The blood test, in opposition to the milk test, is a test of individuals that can be relied on with considerable certitude to indicate which individual animals are infected. One thing especially must not be forgotten, however. A considerable number of animals—most frequently heifers—show no reaction before the actual abortion or even shortly afterwards. But the blood test may—in addition to indicating the infected animals—yield us a pointer as to which animals should be considered especially infectious, as by far the majority of such infectious animals have a high titre of 1:100 or more. We must reckon, for instance, that 90 per cent. of cows with a titre of 1:200 excrete bacteria in their milk.

3. Calves and immature young animals usually quickly rid themselves of the abortive bacteria they have assimilated. But in cows and mature heifers the bacteria have a tendency to establish themselves in the uterus and udder. Cows with infection in the udder often excrete bacteria in their milk and frequently during several lactation periods—in some cases, indeed, during the rest of their lives. The number of bacteria is, however, not very high. As to such cows as have an infected uterus, the excretion of bacteria is limited practically to a period lasting from three or four days before the expulsion of the foetus until a fortnight after. If, therefore, during this period we carry through an effective isolation of all animals that show signs of aborting, of reacting animals that calve at the expected time, as well as of non-reacting animals that calve too early, we can definitely avoid the comprehensive spread of the disease in the cow-shed that would otherwise ensue, and we are able to protect the non-reacting animals from ingesting infectious matter.

4. Outside the period before and immediately after expulsion of the foetus the reacting animals should be segregated as well as possible in a separate group placed nearest the gutter outlet, so that things may be kept extra clean under them, frequent disinfections be carried out, and the (usually small) amount of infectious matter excreted be better eliminated.

5. Vaccination with Strain 19 may produce a considerable degree of immunity, but this is not unlimited; it is neither total nor lifelong, but gradually diminishes and usually ceases entirely when the animal is five or six years old. This point was emphasised in my printed paper, but I would like to be allowed to repeat the fact. In our experience contagious abortion cannot be eradicated by vaccination alone. An improvement in the *status quo* of herds with clinical abortion may be obtained—but much more can hardly be expected. If at the same time the protective measures mentioned before are not systematically carried out the immunity will certainly be broken down. It is quite a characteristic picture that emerges when, in a large-sized herd, the isolation measures are scamped or neglected; it is the young cows in their second pregnancy period that abort. Heifers vaccinated as calves calve normally the first time because calves and heifers are always boxed in a shed by themselves and are only moved to the main cow-shed shortly before calving the first time. But after this first calving the heifers are infected and their second calving time is then interrupted by an abortion.

We vaccinate at an early age—when the animal is between five and seven months old—because by vaccinating later we run the risk that for several years, indeed during its whole life, the animal will react to the blood test; which may, of course, give rise to certain difficulties. Moreover, we also risk that the animal will excrete bacteria in the milk.

6. An animal that has reacted to bovine tuberculosis is lost for ever: it can never more be considered a healthy animal even if, at some later time, it may lose its ability to react to the tuberculin test. But with contagious abortion it is quite another matter, for some of the infected animals may recover from the infection and become completely sound. They will be proof against reaction to the blood test. This tendency to self-purification is even quite dissimilar in different herds; we reckon that about one-fifth of all reacting animals purify themselves and that, in most cases, this self-purification takes place in the course of a single year. Self-purification is most noticeable in fairly freshly infected herds which are being reorganised.

This then, stated but briefly, has formed the basis for our campaigning work in Denmark—a work which, in the course of 10 to 12 years, has resulted in a decrease in the number of infected herds, from about 25 per cent. in the middle of the 1940s to under 1 per cent. in the present summer. But this result is in reality even more amazing than might at first appear, for while the campaign was actually in progress, newly infected and re-infected herds were continually being reorganised and returned to health. This category totalled in round numbers some 25 per cent. We are thus not far wrong when we say that our campaigning efforts have concerned roughly half our Danish cattle herds—that is to say, some 95,000 herds!

By way of comparison we might mention the proved reduction in the number of patients with undulant fever; from 325 as the annual average during the first half of the 1940s down to 70 patients in 1953, and 35 in 1954.

If, in conclusion, we ask ourselves the question: "Was it a difficult task to eradicate contagious abortion in Denmark?" we can but admit it was by no means an easy one. The many new infections and re-infections certainly made the work more irksome than we had imagined at the start. On the other hand, things have progressed far more rapidly than we ever thought possible.

It took us 17 years to overcome bovine tuberculosis—counting from the moment when the work was systematically organised and till the day when a dairy's right to export butter and cheese was made dependent on whether or not all the herds from which it received its milk had been registered as free of tuberculosis. So long a time will not be necessary to eradicate contagious abortion; we may certainly hope to be able to carry our campaign to a successful issue within a single decade.

Finally, I must not omit to mention that the success of our efforts has been due largely to the fact that in Denmark

our farming methods are based primarily on the co-operative idea.

The veterinary directorate has been able to carry on the work in close co-operation with the managements of the various individual co-operative dairies. As a rule, these have not more than 135 members, thus making a suitable unit to work with. The sharing members are bound together by a unity of interests, and every member is interested in what goes on among his neighbours' herds. Moreover, the number of sharing members is not greater than will enable the dairy management to follow the work in individual herds, and it can interfere should any member fail to carry out the duties he and his co-members have undertaken.

The co-operative movement has proved of inestimable assistance in our work, a fact which should, I think, be specially emphasised when venturing to submit this lecture for delivery in the United Kingdom, the country which was, as everyone knows, the original cradle of the co-operative movement.

In the 16th century England was governed by a king named Henry VIII—I am sure you have heard his name before. He had nothing to do with the eradication of contagious abortion, as far as I know, but he nevertheless had plenty of difficulties in his life, particularly of a matrimonial nature and often he changed his Queen. Once when he had just dismissed a Queen a clever man recommended him to marry a Danish princess, Princess Christina. His Majesty declined this proposal with the words, "Marry a princess from Denmark? That cowshed country? Never!" To-day I am here to tell you a little from those cowsheds. I thank the B.V.A. for its kind invitation. It has not only given me personally a great pleasure, but it has also given we Danes satisfaction for King Henry's 400-year-old outburst!

The Chairman thanked Director Nielsen for his introduction and called upon Dr. Mingle to make his contribution.

Dr. Mingle: First of all I should like to express my sincere appreciation of the opportunity to participate in the Association's Congress here in Northern Ireland. This is my first opportunity to visit Northern Ireland and it is certainly a real treat. The wonderful hospitality that has been shown me during the time I have been here has been most graciously given and I have appreciated it a great deal.

I might add in connection with the brucellosis problem that I have more than a passing interest in brucellosis eradication projects in the United Kingdom. As some of you know, I was in the United Kingdom in 1942 and had the opportunity of knowing about some of the schemes that were inaugurated at that time, so I have been following with rather keen interest the progress of the eradication efforts in the United Kingdom.

My paper has covered fairly comprehensively the story of eradication as it has progressed through the years in the United States. I should like to add a little to it inasmuch as we feel that during the past year we have embarked on what we like to call an accelerated eradication programme, which we believe and hope will point the way to very much greater progress in the United States. For many years we have been saying that, given the money, we have the facilities available and we can eradicate or make tremendous progress towards the eradication of this disease. The last Congress in the United States became quite benevolent in this respect. Now the challenge has been thrown back and it is up to us to make good or tell them the reasons why we cannot. We have been in progress on this accelerated programme for a period of about 12 months.

At the time the paper was prepared we had not got the full picture, which is changing all the time, and before I left the United States I was able to get the final figures on how the work is progressing. I have prepared a few slides which I should like to show you. It would seem unnecessary for me to go into details because Director Nielsen has discussed briefly the fundamentals of brucellosis eradication, to which I fully subscribe.

(Statistical slides were then shown.)

The Chairman thanked Dr. Mingle and said it was now his duty and pleasure to call upon Mr. Ritchie to open the discussion. Before doing so, however, he wanted on behalf of them all to offer Mr. Ritchie their most hearty congratulations for the honour recently conferred on him by Her Majesty the Queen.

The Opener

Mr. J. N. Ritchie (Surbiton) said: "It is a great privilege to open the discussion this afternoon. It is of interest to me to do so particularly because 20 years ago I had a similar oportunity at the Congress in this city when I opened the discussion on a paper by Mr. Dolan. On that occasion some of my remarks were ill received in certain quarters and led the discussion into side tracks away from the broad avenue of approach to the problem. I shall try to do better to-day. Indeed I intend to speak in relatively general terms.

"We have before us three papers of real interest and importance. They are important because the disease itself is one which has posed a problem to farmers, practising veterinary surgeons, laboratory workers and public veterinary services for a long number of years. It is a disease which causes direct loss to farmers which can readily be assessed and indirect loss which can only be estimated, and which renders a bill each year for its control in whatever way that control is exercised. It has, too, a public health significance varying with the type of Brucella involved whether it be *melitensis, suis* or *abortus*. The public health problem with brucellosis may be completely solved by eradication of infection from animals, since spread of infection from one human being to another is extremely rare—man gaining infection in one way or another from animals.

"We see in the papers a variety of methods of approach, and we may note from them that there is seldom a method of disease control which can be applied universally. It requires modification to meet the different conditions of environment and the situation in each country. Conditions of environment and stock husbandry, the incidence of disease, the attitude of the farmer, and the degree of co-operation he is willing to afford and the way in which the veterinary service is organised and its existing commitments must all be taken into consideration in deciding how to tackle a disease, whether it be to control it or to eradicate it. It is, of course, essential to know how an infectious disease may manifest itself and how it spreads, to know whether the infective agent may survive outside the host and where and under what conditions it will survive. Equally, there must be a reliable method of confirming observable clinical symptoms, and particularly of diagnosing infection in the absence of such symptoms. Dr. Mitchell's paper is particularly valuable in outlining the considerations which may have to be weighed in deciding on a disease control policy.

"Twenty years ago when we dicussed this disease, although it was only a part of the subject under discussion, we did have methods of diagnosis but they have since been greatly improved. We had a vaccine which was neither safe nor sure but we now have one which is safe and sufficiently sure for practical application, if properly used. Much more important, we have the example of a number of countries which have exploited these advances with results which vary upwards to eradication of the disease. Norway has been completely successful; Denmark, Finland and Sweden have virtually eliminated infection. Great progress has been made in Canada and the U.S.A. as it has to a less extent, for example, in Germany and Palestine.

"Several methods of control are open to us with this disease. First of all, there is the possibility of applying the method of 'test and slaughter.' The method can be applied with success to individual herds if careful precautions against reinfection are taken, but in a heavily infected population its wide application has given rise to some disappointment. This is particularly so because all the safeguards which may be applied do occasionally fail to exclude infection which may be disastrous when it enters an unprotected herd. Further, there is often a degree of difficulty in identifying all the animals which may be infected. A system subject to this sort of drawback does not obtain or maintain support from farming interests. So often it is the failures and not the successes which gain publicity. Before it can be generally

applied, therefore, a good deal of preparatory work is required. Nevertheless, complete eradication must be the ultimate aim.

"In the U.S., and indeed in Denmark, the systems which have been developed allow for vaccination in individual herds to prepare the way for the more positive step of eradication.

"In Great Britain, on the other hand, we have followed the same principle on a different time table. Our aim for the last 11 years has been so to reduce the heavy infection which had built up among our herds that the disease is first brought under control in the sense that the incidence of abortions is markedly lowered, reducing the amount of the infective agent which is likely to reach the susceptible animal. Our system has been to advise the vaccination of adults in the heavily infected herd and to encourage even in the comparatively healthy herd the vaccination with Strain 19 of all young female stock from four months of age to the time of first bulling. (There is evidence that greater protection follows vaccination at the higher ages.) Revaccination at a later age has not been discouraged although experiments now nearing completion may well suggest that little advantage follows from it.

"Vaccination was first officially encouraged under the scheme introduced during the war, fostered by this Association and run along with the N.F.U. and the M.A.F. This panel scheme, which did little to eradicate disease or even to control it if judged solely on figures, did a tremendous amount of good in fostering the approach to animal health problems on a herd basis and brought that approach to the notice of farmers as well as the veterinary profession. This is of real value for there is no doubt an enlightened and co-operative farming community is one of the first essentials to successful disease control among farm animals. We are fortunate in Great Britain in the attitude of official farming opinion.

"In 1944 the Calfhood Vaccination Scheme was introduced and under it increasing numbers of animals are being vaccinated. Nevertheless, there are many left unvaccinated. We have in the region of 3,000,000 cows producing as the possible 1,500,000 heifer calves. Not a third of the calf crop is vaccinated.

"The figures for vaccination under the scheme each year since the scheme started are:

1945	206,000	1950	340,000
1946	274,000	1951	330,000
1947	240,000	1952	371,000
1948	303,000	1953	396,000
1949	313,000	1954	427,000
1955	126,000 (first quarter)		

and about 150,000 to 160,000 doses have been sold from Weybridge each year for private use.

"We can conclude from evidence which is, however, difficult to correlate and from the impression gained from field workers and farmers that the incidence of abortions arising from brucellosis has been very greatly reduced, probably to about one-third of the former frequency. The incidence of infection, particularly as judged by infection in milk, has not followed a parallel course, although there has been a marked reduction probably to about half the former level.

"I am much impressed by Dr. Mingle's attitude to vaccination, particularly his statement which has been stressed here in the past, that the immunity conferred is but relative and that heavy infection will overcome any resistance conferred by the vaccine. Good hygienic measures such as he and Dr. Nielsen mention are clearly a wise corollary to a vaccination programme, which I would look upon as a control measure and not as a method of eradication. The test and slaughter method must, I feel sure, be adopted at some stage to achieve co-ordination. In adopting it we must be in a position to advise the farmer or to lay down the rules about the protection of the herd free of infection. There are all the indirect possibilities of infection mentioned in the papers before us but the main source of brucellosis is likely to be the purchased animal. This means that there must be control of stock movement. The movement of stock that takes place in Great Britain has always been considerable—calves for rearing go from the far south of England to the far north of Scotland; cows and heifers come from the breeding areas in the north and west, bulls and breeding stock are purchased at sales run on a more or less national scale—collected from widely scattered areas and distributed as widely, but there is and has been for some years an inordinate movement of cattle from attested herds and areas to fill the gaps in herds undergoing eradication of tuberculosis, or to reconstitute herds which have been disposed of during that process. So high was our incidence of tuberculosis that the necessary movements of stock during the eradication campaign have multiplied and the process still goes on. All this traffic carries a great potentiality for spreading infection other than tuberculosis and it is a great tribute to Strain 19 vaccination in such a background that the abortion rate has fallen as it has.

"It appears to me that for some years to come the control of brucellosis in Great Britain must depend primarily on vaccination. It has been suggested that the areas cleared of tuberculosis might be the first to be cleared of brucellosis, but these are the areas from which stock is moved in large numbers to the herds undergoing tuberculosis eradication and we should simply be encouraging the movement of stock highly susceptible to brucellosis into infected herds unless vaccination in these areas is continued, encouraged and more widely applied.

"It may be better to wait until tuberculosis is nearer elimination before we encourage eradication of brucellosis and it would in the early stages still require to be accompanied by calfhood vaccination. Incidentally, it will be noted that the countries which have been mentioned as having made the best progress with brucellosis are those which had earlier virtually eliminated tuberculosis.

"We have also to consider the possibility of being able successfully to carry out a programme of eradication which involves a heavy burden of blood testing. It would appear that nothing may be lost by being cautious, for it is evident that in supplement to the blood testing of samples from individual animals, the ring test of herd milk samples to screen the herds may be useful and other tests to discover antibodies in the vagina or uterus may become available to assist in the identification of every infected female. If the ring test were adopted for screening it would be necessary to confine vaccination to cattle of six to nine months of age.

"A feature that has been of interest in Great Britain in recent years is the recovery from cattle of organisms with all the characters of *Br. melitensis*. When this type of infection was first discovered the whole herd of cattle was slaughtered without any salvage of carcases. However, there has been no evidence of infection in humans on any of the occasions when the organism has been involved in spite of close contact with infected cattle, and even when raw milk from the herds had been consumed. Only the affected cow is now slaughtered as a public health precaution. Other than this type of infection only *Br. abortus* has been recovered in Great Britain.

"There are two specific questions I want to put to Dr. Mingle. I notice he speaks of the falling incidence of positive reactors in the test and slaughter herds. I gained the impression at an earlier date that these figures are a little misleading. I gathered that if a herd becomes heavily infected it no longer remains under the test and slaughter scheme but reverts to vaccination for control—so that the figures for that more heavily infected herd would not appear in the statistics of the test and slaughter herds. In consequence, the incidence of reactors is bound to remain fairly low since, in a sense, the herds are selected. Can Dr. Mingle tell us if my impression is correct?

"Could he also say something about the use of dried vaccine? It appeals to me as particularly attractive in view of the delicacy of the vaccine and the expected death rate of organisms in it, unless it is transported and stored in the most favourable conditions. Indeed we are preparing for the use of dried vaccine in Great Britain."

The General Discussion

Dr. W. R. Kerr (Stormont) said that he wanted to congratulate the Association on putting forward an international paper, and to congratulate the authors and the opener. The question of animal health, public health and agricultural

economy were tied up with the subject before them. They at Stormont were interested in Brucella diagnosis. Dr. Mingle in his paper referred very rightly to experiences which emphasised the importance of establishing and maintaining confidence in the diagnostic procedures employed as part of the eradication project. That was very important and one aspect which had rather stood still was the diagnosis of brucellosis. The blood test had been relied upon and, of course, a lot had been done to standardise the antigen.

In the venereal conditions it had been shown that the germ and its antigen were present in the uterus. These were antigens which did not under normal conditions pass into general circulation and therefore they did not produce antibodies in the general system. The blood test could not be used satisfactorily in those conditions. The same thing applied to *abortus*. Once germs were in the uterus they grew and developed and produced a condition leading to abortion. On the other hand, the antibodies produced in the circulation did not reach the uterus. An animal could be vaccinated but antibodies would not appear in the vagina, and conversely high titres, *e.g.*, up to 20,000 could be produced in the uterus from the living organism and yet nothing might appear in the blood.

Eleven experimental animals were infected at the time of mating and seven did not show a blood titre exceeding 1:20 for five months and then as they approached abortion the titre rose. The organism and its products before abortion became excreted into the vagina, absorbed, and blood titres started to be produced. Titres produced in the vagina had been shown to be the result of active infections. With animals which had been vaccinated the breakdown due to active infection could be determined by the vagina mucin test. The value of this test was that it enabled one to determine whether an infection was vaccinal or active in origin.

In Dr. Kerr's opinion any animal with a complete titre of 1:10 must be considered to have had experience either of vaccine or the living organism. It was not uncommon to have an animal with a blood titre of 1:20 and perhaps indicating udder infection and uterus infection but without general infection. The presence of titres in the milk also indicated an active infection. Had Dr. Mingle any experience of heat treatment in the U.S.A. in relation to pasteurisation and milk antibodies?

The stage had arrived when they could usefully consider the results of the ring test, the spot test, and the vaginal test in relation to the blood test and the clinical story.

Dr. A. W. Stableforth (Weybridge) referred to the FAO/WHO international committee on brucellosis. It took a great interest not only from the bovine point of view but also from the point of view of infections in sheep and goats in other countries and from the human aspect. Sizeable experiments were being carried out by the FAO and WHO and the Tunisian authorities to find out whether it was possible to vaccinate against *Brucella melitensis* infection in sheep and goats. The line of vaccination was taken because in so many of the countries concerned—though it might be a little difficult to realise this in Britain, the Scandinavian countries or the U.S.A.—people were not yet educated in disease eradication methods and conditions were such that an eradication programme based on blood tests would not have much chance of success. It had in the first place been necessary to define a challenge dose for goats and sheep from which one could know what to expect in the tests of vaccinated and control animals. Turning to cattle, it was a piece of work of the greatest importance, and something people in Britain had to be very grateful for, that Dr. McEwen and his colleagues had carried out experiments in 1937 which established critical challenge doses for testing vaccines in bovines—doses which had been used ever since at Compton and had given a volume of information of the very greatest value. It was to be hoped that their present series of experiments would soon give the needed information on the duration of immunity and the effect of one or several doses at different ages. Would Dr. Mingle tell them the present American thought on the duration of immunity? Dr. Nielsen seemed to feel that even at the second calving there was a decrease in immunity. Mr. Ritchie had said that experience here suggested that immunity did not decrease with age. It appeared that one dose did give a fairly long immunity, and even if it did not give anything like an absolute immunity but was sufficient to take the edge off susceptibility for a long enough period it might be of great use as an adjunct in an eradication programme.

Speakers had emphasised that vaccination did not give absolute immunity and that was something of great importance domestically because, as with all bacterial vaccines, it certainly did not. When complaints of vaccine failure were made sometimes the vaccination had not been done properly but in many cases vaccination had been carried out exactly as one wished and it failed. The reasons were being sought by examination of the strain concerned and in other ways, but complete immunity could not always be expected and therefore all possible precautions must be taken to stop the vaccine being imposed to too great a challenge dose.

The next question concerned the age for vaccination. The six- to eight- (or nine-) month period had been taken because of the reactions remaining from vaccination if it was done later and the belief that vaccination was less satisfactory earlier. Dr. Nielsen said five to seven months was used in Denmark and it would be interesting to hear a little more of American and Danish thought on vaccination at five months because even when one laid down five months a number of animals probably were vaccinated under five months and one had the impression that was not a very good thing.

It was important to realise that when agglutination titres of 1:100 or 1:200 were referred to it did not necessarily or usually mean the equivalent of 1:100 or 1:200 in Britain. 1:100 in the U.S.A. and certain other countries was equivalent to 1:40 in Britain. Dr. Kerr had referred to a titre of 1:10 and that in America meant something very different from what it meant in the United Kingdom. Tests were conducted in different ways and it was important that the relation of the titres should be expressed by reference to the international standard serum.

Mr. J. W. Macaulay (Kenya) said that he wanted to raise one or two points that would probably not be of benefit generally. Kenya, as a country endeavouring to export butter, etc., had to tackle the question of brucellosis during 1955. Strain 19 vaccine had been used there for nearly 20 years with insufficient success. The only result was that the so-called abortion storm did not occur, but the percentage of infection was still in the region of 10 or 8 depending upon the year for which one took figures. There were fewer than 100 veterinarians in the whole country. It had been in a way amusing to read in THE VETERINARY RECORD recently of the furore because veterinary surgeons in the United Kingdom were not receiving their copies of THE RECORD by Saturday morning so that they could read them over the week-end. When Mr. Macaulay had left Kenya recently to attend the Congress he had not received his copies of THE RECORD or papers which were posted about May.

A survey had been made at the request of the Kenya farmers. A scheme was being recommended to the Government and an endeavour had been made to use the varied information reported in previous years from America, Scandinavia and Britain, and the papers under consideration would doubtless be of tremendous value.

Could Dr. Mingle tell them anything about the satisfactory survival time of a milk sample in transit? In Kenya there were large distances to be covered and the postal service was slow. Dr. Mingle had made a reference to compensation being paid in respect of slaughtering. Propaganda had been put out to farmers' unions in Kenya urging districts to agree to the branding of reactors, with a view to cutting down the time for which reactor animals might be available and it would be interesting to know if the full market value for such animals was paid in the U.S.A.

Dr. Nielsen had referred to the compulsion brought about in Denmark. It was difficult to enforce compulsion in Kenya. For such diseases as East Coast Fever it had been possible with a two-thirds majority at a statutory meeting to bring in legislation, but East Coast Fever was a killing disease whereas brucellosis as yet had only a mild effect on the farmer's pocket and was of little public health significance

in Kenya. Could a little guidance be given with regard to compulsion.

Professor A. Robertson (Edinburgh) said that he had enjoyed Mr. Ritchie's contribution but could not help being disappointed with the conclusion reached. In that connection he would like to ask Dr. Nielsen if the procedure in Denmark had been to wait until tuberculosis was eradicated before tackling brucellosis for it was his impression that their Danish colleagues had started brucellosis eradication while they were still quite a way from the complete eradication of tuberculosis. There had been a suggestion that the United Kingdom might start its eradication of brucellosis in attested areas but Mr. Ritchie had given very weighty reasons for not trying that for some considerable time to come. Professor Robertson doubted, however, whether the dangers and difficulties were quite as great as had been suggested; and certainly if they had to wait until they had nearly eradicated tuberculosis over the country as a whole before they took steps to tackle the brucellosis problem, they would have to wait a very long time before coming within measurable distance of eradicating the latter disease. Surely it was hardly necessary to wait as long as that before taking further steps in this matter.

It was certainly true that to send attested animals completely free from brucellosis to areas where there was widespread infection could be disastrous, but the matter was surely not quite as simple as that. When tuberculosis was eradicated in certain areas, if the eradication of brucellosis was then started it would inevitably take quite a long time before they achieved this latter objective and the process he envisaged would be something like this. There would first have to be a much more widespread vaccination in the attested areas to spread the immunity more widely than at the present moment. The next stage would probably be vaccination plus eradication, possibly on the Danish lines, and then would come a third phase in which they would be able to concentrate on eradication alone. Only at the end of that time would there be the danger referred to of sending out completely susceptible animals. That would take many years to achieve, by which time, doubtless, many areas in the country would have the disease thoroughly under control. A start could surely be made, therefore, to get vaccination adopted more widely in attested areas after which they could proceed with eradication in individual herds and then with area eradication. In his view that could be undertaken without awaiting the complete eradication of tuberculosis and he felt that the time was now ripe when they might commence with a procedure of that sort without the risk of the dangers mentioned by Mr. Ritchie being too excessive.

The Replies

Director Nielsen, in reply, said that the reason for early calf vaccination in Denmark was the fear that the animals would never lose the reaction if vaccinated at too late an age. In Denmark compensation was paid partly by the creameries organisation and partly by the State, and if an animal gave a reaction because of vaccination it could be a very expensive thing for the creamery as well as for the State. Experience showed that the best age for vaccination was between five and seven months. Formerly, the right age was considered to be between eight and 12 months. During the last years there seemed to be greater success in the vaccination programme with Strain 19.

As regards compulsory and voluntary measures, it was difficult to explain the position in Denmark in a few words because of the strong co-operative system there. The co-operative creameries had their local laws. They had an average of 135 members and there was a great advantage in working for such a limited number of shareholders. The chairman of the creamery and his committee knew all the shareholders and everyone was interested in what was happening. Although it was difficult to say what measures were compulsory and what measures were voluntary, anyone sufficiently interested could study the foundation of Denmark's co-operative movement.

Before proceeding with the eradication of brucellosis, Denmark did wait to eradicate tuberculosis. He would not recommend farmers to start on the eradication of brucellosis until tuberculosis was finished with, otherwise it would be too complicated. There were breeding factors and economic considerations to take into account, and to deal with tuberculosis and contagious abortion at the same time was not practicable.

Dr. Mingle, in reply, said that the possibility of retained reactors in infected herds being responsible for some probable inconsistency with respect to rates of infection was a factor that Mr. Ritchie had called attention to. It was a valid factor. An absolutely true picture was not being obtained from the results compiled. In his country it was required that retained reactors be limited to a period of three years. It was not permissible for reactors to be retained on infected premises for longer than that period.

Vaccinations were considered to be extremely valuable. A great number of the failures in the past were doubtless due to the use of non-vitality or low vitality vaccines. In many cases vaccines were used although there was some doubt about their potency. About a year previously a recommendation was made that no more liquid vaccine should be permitted on the market. That would be an extremely wise move. The overall cost would be a definite consideration, but the overall effect would be well worth it. There were at present in the United States about four commercial companies which were producing large quantities of desiccated vaccine and more were putting in equipment which could handle the same type of production. About five to eight cents more per dose was being paid for such vaccine than for the liquid, so the additional cost was low when the extra value of the product was borne in mind.

The titres he had spoken of, as Dr. Stableforth said, were considerably different from those used in Britain. The antigen used at one time in America was about five times more sensitive than that used in Britain. With regard to the possible effect of pasteurisation on titres in milk, certainly overheating would knock out Brucella agglutinins. Heating milk samples at 65° C. for one hour would materially reduce the non-specific reactions. It did not take away all of them, nor did it take out specific agglutinins. Recent work at the University of Minnesota showed there were at least two broad categories of non-specific substances found in milk that might affect the APR test. It had been found also that those which were heat stable were susceptible to acetic acid. Apparently, agglutinins would stand a great deal of heating.

The question of duration of immunity in regard to Strain 19 vaccine had been raised. The vaccination resistance obtained in properly vaccinated animals was probably not a steadily maintained degree of resistance. Under normal conditions one gradually got a subsidence of bacterial resistance which was largely compensated by a natural growing resistance developed by the animal on its own. A single vaccination was adequate if done in the way recommended. At the beginning a use of vaccination was encouraged along with a plan of animal husbandry which gradually removed the infected animals out of the infected herd. Over the period of time involved in that, about three years, there was created a serviceable degree of resistance resulting from the vaccination. There was no apparent value realised by re-vaccination of cattle. Some very critical work had been done in which groups of animals with a single vaccination were compared with animals that were re-vaccinated, and controls, and there was no detectable difference between the animals vaccinated once and those vaccinated twice, so re-vaccination was not being encouraged. To begin with, the age recommended was from four to eight months, but gradually, as it was felt that an animal was eight years of age until it was nine, many animals were being vaccinated when almost nine months old. Then the minimum age was moved up to from six to eight months. That was not done because it was felt there was inadequate resistance at four months. There was plenty of evidence to show that an animal vaccinated at four months gave a reasonably serviceable degree of resistance. To state a categorical limit on age was a little unfortunate.

One would like to think that the practitioner or man in the field would use a little common sense in the administra-

tion of vaccines and in determining the age for vaccination. In vaccinating a herd in which there had been no history of infection for a number of years, Dr. Mingle personally would want to stay at the low limit. The animals would be more responsive than those which had been in an infected herd. The risk in vaccinating at a young age was minimised in that type of herd. The main thing seemed to be the use of a little good judgment and the man who knew the history of an animal should be the best judge of the age at which to vaccinate.

Under the accelerated programme the age for vaccination had been changed a number of times. Four to eight months was now recommended as the age because many States had a requirement in their statutes for official vaccination to be carried out in that period, but, in fact, the age preferred was from six to eight months.

Mr. Macaulay had spoken of survival time in relation to samples and it was difficult to give precise information about that. Survival of milk samples up to 72 hours was achieved without difficulty by the addition of one or two drops of formalin to about 5 c.c. of milk. Even in warm weather little difficulty was experienced in connection with this in the United States. Mobile laboratories were employed to assist, because high acidities developing in the milk made the effect in the ring test most confusing. It was important to have good quality milk for the ring test.

Lack of success in vaccination was difficult to explain and one wondered what was responsible for it. In the United States there were areas in which vaccination had been conducted over five or ten years, and in one of them infection was reduced from 7½ per cent. to 2½ per cent.

For the purpose of indemnity the animals were considered as healthy animals and were valued accordingly, the fact that they were known to be infected with brucellosis being disregarded. It was paid if animals were removed from the herd within 15 days or, if about to calve, 30 days.

The Chairman thanked Dr. Mingle and said there was one point he would like to add to save a slur on the British Post Office. In fact the papers had been posted about three weeks previously, and not in May as Mr. Macauley had thought.

It remained only for him to thank the essayists who were present—as well as Dr. Mitchell—for having crossed the North Sea or the Atlantic Ocean as the case might be, in order to address them.

The Veterinary Surgeon and the New-born Foal

BY
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Dublin

A STUDY of the problems in rearing the thoroughbred foal must not only include the ailments in the individual foal, but should also embrace those conditions which may give rise to, or at least encourage the spread of, infectious diseases amongst the newborn. While it is not the intention to pursue these predisposing factors in detail, a superficial survey may not be out of place.

In an industry which is over 200 years established, and which from the beginning has always had considerable financial backing, it is rather extraordinary to notice how lacking it has always been in scientific application. Over the last 50 years or more many well-written, sound books have appeared on animal husbandry, management and hygiene, but the application of the views expressed has found little or no place in thoroughbred breeding.

In the last two decades this state of affairs has changed slowly but considerably, and many countries have bloodstock breeders advisory societies and research bodies, *e.g.*, The Animal Health Trust in England. To my mind, however, the industry has been too long established for these associations to have had the influence they should, particularly on stud buildings and stablings, which have such a direct bearing on good hygiene as we know it to-day. There are very few studs in England or Ireland, or for that matter in most parts of the world, that are ideal by modern standards for the rearing of bloodstock. Together with this, since the last war, a great number of new studs are mushrooming up and are built around, to a great extent, good handicap type of stallions. With the great cost of building and lack of capital, buildings in these studs are in a great many cases makeshift and of a lean-to type. In these we find little or no consideration given to ventilation and insulation—two factors which have a tremendous significance on the health of stock on a stud farm. These remarks are in no way to be taken as adversely critical of stud owners, with whom the profession is in sympathy, but are mentioned to emphasise the factors which may adversely influence the treatment of the individual animal and the control of epidemics.

The most vulnerable period in the foal's life is the first 14 days, of which the first three are vital. In these 72 hours one may expect to find any of the following conditions, which require prompt veterinary attention:—(a) septicaemia (including joint ill), (b) acute gastro-enteritis, (c) retention of the meconium, (d) haemolytic disease, (e) congenital deformity of the limbs, (f) abnormalities of the umbilicus, (g) rupture of the bladder, (h) barker and wanderer, (i) eye conditions.

Septicaemia

As advocated by many equine workers, the administration of 500,000 units of penicillin and ½ gramme of streptomycin to all foals as soon as possible after birth, is very well recommended, and it is unquestionably responsible for the very marked decrease in the incidence of shigella viscosis infection, which gives rise to the sleepy foal syndrome, and to streptococcal septicaemia. Where this prophylactic treatment is not sufficient to counteract the infection, it would appear that it delays its onset for up to 48 hours, which, of itself, materially aids the young foal. The classification of foal infections has never reached any uniformity and it is intended here to describe briefly the more common septicaemias and to conclude this section with a reference to joint ill, which may become a complication of any of these bacteraemias or toxaemias.

Shigella Viscosa

The symptoms usually found are lethargy increasing hourly; slightly raised temperature—about 102.5° to 103° F.; injected, but not markedly so mucous membranes; slightly increased respirations; pulse rate up to 100 per minute. The foal in the early stages continues to suck normally but remains only short periods on its feed and spends most of the time sleeping. In the later stages nephritis becomes apparent and is evidenced by marked tenderness in the loins and passage of urine in small quantities. The lassitude becomes more marked and the foal usually goes into a deep coma in about 48 hours from onset.

The condition responds to any of the following antibiotics, 1 gramme streptomycin *t.i.d.*, achromycin 2 grammes *b.i.d.*, chloromycetin 2 grammes *b.i.d.* (as well as some of the less common proprietary products). In the early stages any one of these, given by the intramuscular route, and continued for at least three days after all symptoms have disappeared, should effect a recovery. In the more advanced cases, achromycin or chloromycetin intravenously in 250 mg. doses, together with the 2 grammes intramuscularly, is favoured. Where feeding has ceased 6 oz. of mare's milk are fed per stomach tube every three hours. This may be supported by saline intravenously (500 c.c.) or, better still, 500 c.c. whole blood. Caffeine and coramine have frequently been found very useful in cardiac and respiratory embarrassment.

It is interesting to record here that last February shigella in pure culture was isolated from the stomach of an aborted seven-month foetus submitted to Professor E. Mullaney of the Veterinary College, Dublin.

Streptococcal Septicaemia

Septicaemia due to haemolytic streptococci is frequently encountered. While it is impossible clinically to distinguish with certain accuracy between the different types of septicaemia, it is felt that when the infection becomes established, the most definite symptoms are found in the respiratory tract, and in limb articulations. Both these types are associated with a marked pyrexia, usually around 105°F., but occasionally as high as 107°F. Treatment here, of course, is penicillin in massive doses. It is usual to commence with 5,000,000 units sodium salt and maintain blood levels with procaine penicillin. The reason for the initial change to the procaine salt is that the latter is better tolerated locally, and consequently one is more likely to maintain the confidence of the animal and eliminate the fear that frequently arises as the result of irritant, or at least uncomfortable, injections. As already stated, the type of infection is frequently not apparent, and to guard against such shortcomings, the administration of 1-gramme doses of streptomycin together with the penicillin should be routine procedure. This treatment is continued for 60 hours from the time the temperature has become normal.

A brief reference to body temperatures may not be out of place here. Normal healthy foals usually record a temperature varying between 101° and 102° F. and occasionally up to 102.5°. However, while on antibiotic therapy it is invariably found that the temperature becomes sub-normal (based on the above figures) in the region of 100° to 100.5° F. and will remain in this latter range for some days after cessation of treatment; consequently one is never satisfied that treatment is complete until this sub-normal temperature has been maintained for at least 60 hours or, better still, 72 hours.

Joint Evil or Ill

This manifestation of disease is understood to be peculiar to equines up to about six months old. It is evidenced by the sudden marked inflammation of one or more of the articulations and/or serous sheaths and bursae of the limbs, with associated pyrexia and acute lameness. While it is obviously the result of an infection, and responds to antibiotic treatment, oddly enough the synovial fluids remain sterile. As the condition is often stubborn to treat it frequently necessitates the administration of massive doses of penicillin and streptomycin. If, however, symptoms are severe and initial response is poor, achromycin or chloromycetin intravenously is substituted for the streptomycin. This season a number of spectacular results were obtained with the injection of hydrocortone into the affected joints. No good reason is offered as to why the hydrocortone could not have been incorporated in the initial treatment, but so far it has not been administered till an initial response to the antibiotics is evidenced by a drop in temperature.

Relapses are very likely, and to overcome this difficulty it is suggested that the essential advice to clients is to ensure complete rest in the stable for at least 21 days. During this time daily temperatures should be recorded and thereafter exercise should be of a restricted nature for some weeks.

Acute Gastro-Enteritis

The cause of this condition is invariably attributed to *B. coli*. As it is highly infectious, and very resistant to control unless rigid disinfection is carried out, this creates a little doubt whether *B. coli* is solely responsible, and suggests that perhaps Salmonella may be considered as a contributory causal agent. This theory is supported by the high incidence of the disease once it has been introduced into studs early in foaling season, particularly where good hygiene is difficult owing to the use of old buildings and where timber structures predominate.

While foals at any age may be affected the condition is most frequently seen about two to five days old, and the younger the foal the more severe the symptoms. The onset is sudden; what may have appeared a perfectly healthy lively animal becomes dull a few hours later, is listless and dejected, with a profuse watery foetid diarrhoea, pyrexia in the region of 103.5° F., increased respirations and cardiac rate. The patient rapidly deteriorates, depending on the rate of dehydration. The foal usually continues to suck though with decreasing vigour for up to four or five hours from the onset of diarrhoea, and on this point is based the intensity of treatment. If a foal is sucking reasonably well at the commencement of treatment, one can be satisfied and confident to rely on an intramuscular injection of 2 g. chloromycetin or a similar amount of achromycin. Response is frequently spectacular, being apparent in as short a period as six hours, at which time a particular point should be made of revisiting the patient. In the last two stud seasons during which a great number of foals were treated at this early stage, not a single case was recorded in which all serious symptoms had not disappeared in 10 hours. A point, however, is made of repeating the antibiotic in 12 to 16 hours, with a final treatment 24 hours later.

The necessity for this was clearly evidenced this season, by the death of a foal which had previously responded in less than six hours to initial treatment. The owner was so satisfied with its apparent complete recovery that he considered further treatment to be absolutely unnecessary. The foal was found dead at morning stables about 48 hours later. *Post-mortem* examination revealed lesions of acute septicaemia with marked ulceration of the stomach and small intestine.

To those cases encountered at a more advanced stage, achromycin or chloromycetin 250 mg. intravenously are administered together with the usual 2 grammes intramuscularly. As dehydration has now become the major issue, 500 c.c. of a proprietary saline and cellulose preparation are administered intravenously. This may be supported by another 500 c.c. normal saline with hyaluronidase, given subcutaneously in the pectoral region. In extreme cases 500 c.c. whole blood are administered. Salines are repeated at six-hour intervals and are continued until such time as the diarrhoea has ceased and the foal has commenced to suck—the latter should be the

deciding point as to when transfusion may be terminated. The antibiotic is administered by intramuscular route at eight-hour intervals until cessation of symptoms and thereafter at 12- to 16-hour intervals for 48 hours. No treatment is given orally and forced feeding by stomach tube is not advocated.

Retention of the Meconium

This is by far the most usual of foal problems in thoroughbred studs and has been attributed to impaction of the small colon and to intestinal anatomy. That it occurs more frequently in colts than in fillies suggests that in the pelvic formation is more likely to be found the more certain explanation. This is supported by the *post-mortem* examination of two foals which died as the result of this retention. In each case the pelvic orifice was so narrow as to prevent the free passage of the little finger. The lack of opportunity to exercise must play quite a big part in retarding development of muscle and tendon tissue, which occurs so rapidly after birth, and this in itself must have some bearing on the opening up of the pelvis, which has been compressed considerably *in utero* and during parturition.

Symptoms are those of spasmodic colic with frequent straining and attempts at defaecation. Foals continue to suckle with normal vigour, there is no febrile reaction, the pulse, which may be rapid during spasms, remains full and strong.

Treatment by the surgical removal of meconium with instruments is not advocated, complete reliance being put on laxatives and lubricants *per os*, and enemata per rectum. Liquid paraffin and glycerine (equal parts) in 3-oz. doses are administered every two hours, together with enemata and glycerine suppositories. These are continued until the meconium becomes soft and cream-like. Some cases have run up to 72 hours before relief, when quantities of up to 8 litres of paraffin and glycerine have been administered. The average duration, however, is about 24 hours.

Hymolytic Jaundice

A brief reference only to this important disease is intended, as it has been dealt with very extensively by English and American workers in the last two years. Full agreement as to the cause has not yet been reached, some maintain it is essentially a blood group sensitisation while others insist it is due to a blood factor similar to the rhesus of the human. Fortunately, there is no disagreement on treatment, which is one of exchange transfusion of up to 8 litres of whole blood, which has previously been found suitable by cross-typing.

Symptoms are those of anaemia which may be peri-acute, acute, or mild, depending on the rapidity of inactivation and destruction of the red blood cells. The onset may be so rapid and severe that foals may be found dead. In others at from 12 hours to 24 hours old, there may be first noticed difficulty in getting up and down, which rapidly develops into complete exhaustion and collapse. The pulse becomes rapid and weak, the temperature usually sub-normal, respirations rapid and shallow, membranes pale. Jaundice may first be noticed on the pearly white of the selera of the eye. Positive diagnosis is made on blood examination. Cronin (1955) states that transfusion where the R.B.C. count is 2,000,000 or less is hopeless, but in practice it may well prove successful in a small percentage of cases and should at least be attempted.

The method of transfusion adopted is that described by Cronin using the three-way adaptor to a hypodermic syringe and polythane tubing. A point worth considering is the temperature at which the collected blood should be kept when transporting it from the donor to the place of transfusion, which on occasions may be a considerable distance. This is particularly important in adverse weather conditions. The natural tendency is to retain the blood in a heated water bath which may if not checked with a thermometer be greater than blood heat. Should this be allowed to occur, it may change the protein nature of the blood and itself give rise to shock with cardiac collapse and death during transfusion. To avoid any error in this direction, "cold blood" (blood in which no effort is made to maintain body temperature) is now used at each transfusion. Three such operations were carried out last season, each of which was uneventful and successful. In one of these, the blood was transported about 20 miles in an atmospheric temperature just above freezing. Prophylactic antibiotic and vitamin therapy is essential for some days after treatment. Anticipation of the condition in pregnant mares by serum tube estimation some weeks before parturition (Miller & Farrelly, 1954) is highly successful, the progeny of reacting mares being prevented from suckling their dams for 36 hours. Substitute feeding can be found in any of the proprietary half-cream human baby foods which would appear to be eminently suitable to foal digestion.

Congenital Deformities of the Limbs

The more important deformities are of two types and involve the flexor tendons and suspensory ligament. They are in the form of contraction or relaxation of flexor tendons and/or suspensory ligament.

By far the most common is the contraction of the suspensory ligament which in a mild case is responsible for the normal slope of the pastern not being attained, the limb being perpendicular from the carpus to the hoof at rest. On movement the familiar "knuckling over" of the fetlock occurs at each step. Both fore limbs are usually involved, the conditions being uncommon in the hind legs. Where contraction is further advanced the foal is unable to place even the toe of the hoof on the ground and attempts to walk on the front of its fetlock. In mild cases of contraction of the flexor tendons the foal "stands over" at the knee and is unable to attain the normal perpendicular from elbow to fetlock. More exaggerated cases of flexor contraction are usually associated with that of the suspensory ligament, and here the foal is unable to attain a standing

position, the limb having a hooped appearance, due to flexion of the carpus and phalangeal joints.

Over a great number of years a method of splinting, devised by J. J. Cosgrove, has been successful in a large number of cases treated. The method, which requires the assistance of a good blacksmith, is comparatively simple. Within 24 hours of birth the foal is shod with a light iron shoe, using the finest type racing nail. Welded to the toe of the shoe and projecting in front of it and on the same horizontal as the bearing surface is a metal perforated disc about the size of a shilling-piece. The metacarpus is then put in a strong plaster cast, the area to be plastered being first protected by strips of adhesive felt, taking care not to involve the fetlock articulation. The splint is a heavy aluminium strip about 16 inches long and 1 inch wide, to the extremity of which has been welded a small metal hook at right angles to the surface of the strip. This hook is passed through the perforated disc of the shoe, forming an eye and hook joint, whereby the strip of aluminium may be swung back to the anterior surface of the plaster-casted metacarpus to which it is bound by adhesive plaster. By manipulating manually the shape of the strip, prior to strapping to the metacarpus, forced extension of the phalangeal joints is attained. The strip is adjusted at 12-hour intervals, extreme extension being sought at each adjustment. On first application one can always get the foals to present the toe to the ground, in fact they walk on the disc projection which may be likened to tiny stilts. The amount of extension that can be found in a short period is surprising. In two cases of extreme suspensory contraction treated this season, both attained normal sloped pasterns in five days.

[A specimen splint will be exhibited by a commercial firm during Congress.]

Relaxed Tendons

Common in "badly done foals," usually the progeny of dams on low protein diet during gestation. Such mares are often deceptive in appearance, being in apparently excellent condition, which is entirely due to excessive fat deposits. Vitamin B complex together with Vitamin A and D is useful, but the opportunity of the foal getting voluntary exercise in the paddock from 12 hours of birth, or earlier, gives the greatest and quickest results. The prejudice of stud managers against "letting out" foals under four days old is well established but, except in adverse weather, such as frozen ground, it is well worth overcoming. Similarly, lateral deviations of the limbs, particularly those of the carpus and tarsus, will improve rapidly with exercise.

Rupture of Bladder

This condition has been described by Day, Crowhurst *et al.* The cause is usually attributed to undue compression of a distended bladder at foaling, but as it has been encountered in a 10-day-old foal it is more than likely it occasionally occurs as a result of strenuous exercise in a very active foal.

Definite diagnosis in the early stages is difficult, and the condition is frequently confused with retention of the meconium. Straining attempts at micturition (urine may be passed in small quantities) are very similar to those observed in the course of passage of meconium. Aspiration of air through the urinary catheter coinciding with respirations is often a useful guide. When the condition has been present for three to four days little difficulty is found in arriving at the correct conclusion. Definite symptoms are present of uraemia associated with a pendulous abdomen.

Treatment is straightforward laparotomy and suture of the rent in the bladder wall which is invariably on the dorsal surface. Supportive postoperative treatments, apart from those demanded surgically, are intravenous salines or blood transfusion as the gravity of the case warrants.

"Barkers" and "Wanderers"

These names have been applied to foals showing symptoms of nervous origin which may be closely related, if not identical. They vary only in relation to the degree of cerebral involvement. The cause is not understood and no research findings have as yet been published. The mortality rate in "barkers" is about 50 per cent. and carcases are as a rule sterile for infection. *B. coli* has been isolated in pure culture from the liver of one foal submitted to the pathology department, Dublin Veterinary College, but this was possibly coincidental.

The "barker" is so named because it emits a sound not unlike a dog's bark, which may be first noticed as early as 15 minutes after foaling. The foal appears extra active in efforts to gain its feet, which position is seldom attained. When it succeeds in doing so, stance is usually only momentary. Occasionally one sees symptoms which may only be described as those of acute mania, such as charging into walls or any structure which may come in the foal's way.

Treatment is symptomatic and varies from sedation to deep narcosis. Since rather similar symptoms have been described by American workers in foals affected with meningitis due to *Shigella viscosa*, antibiotic therapy is well worth considering. Feeding per stomach tube is carried out at three-hourly intervals during the first 24 hours. Should symptoms reappear with recovery from the narcotic, deep anaesthesia is again resorted to. If, however, symptoms desist, the foal is encouraged to get to its feet. At this stage blindness and inability to suck are usually noticed, probably due to paralysis of the cranial nerves involved. This latter state resembles very closely what is described as the "wanderer" foal. This type does not go through the excitement stage, but is born blind and, apart from its inability to suck, has no inclination or instinct to do so. Treatment here is one of good nursing with adequate and regular feeding per stomach tube. The administration of antibiotics, and vitamin therapy have everything to gain and nothing to lose. Some improvement is usually noticed between the 36th and 48th hour. This is particularly evidenced by the

appearance of weak sucking movements, and as these become stronger tube feeding should be gradually replaced by bottle feeding with a rubber teat, and this in turn by natural feeding. Recovery as a rule is complete about the fifth day, sight being the last sense to recover.

Eye Conditions

Injuries to the eye and eyelids are common minor ailments which, if they do not respond to treatment or are neglected, may become permanent major defects in the adult horse. Blepharitis, entropion and opacity of the cornea are frequent sequels to direct injury, especially noticeable after protracted cases of retained meconium. Entropion, if early corrective treatment is not carried out, may quickly produce opacity and ulceration of the cornea.

The method described by Day, of suturing together two folds of skin immediately below the eyelid, is the method of choice; it is usually permissible to remove the suture within five to seven days.

The use of hydrocortone ophthalmic ointment has revolutionised the treatment of blepharitis and opacity of the cornea. This ointment may be used in conjunction with an antibiotic where any doubt arises as to whether the cause is bacterial rather than traumatic.

Umbilicus

The old established practice of "tying off" the umbilical cord a couple of inches from the abdominal wall is not recommended. Instead it is now usual to rupture the cord without the application of any ligature whatsoever.

Following ligation, the consequent retention of a small quantity of blood in this portion of the cord becomes an ideal breeding ground for bacteria with subsequent abscess formation. These frequently develop immediately inside the abdominal wall and are not apparent except on very close examination. The focus of infection in young foals which have died from tetanus is invariably found at this site. These abscesses may also be the source of low grade infections and explain the cause of many unthrifty foals.

Pervious urachus is occasionally encountered and responds immediately to suitable suturing; abscess formation in the vicinity should be carefully noted and treated, otherwise serious complications may arise.

Summary and Conclusions

1. Brief reference is made to the low level of hygiene which would appear to be the direct result of expert advice not being sought prior to the erection of stud farm buildings.
2. Short notes are presented on aetiology, symptoms and treatment of the commoner infectious diseases of the newborn.
3. Compression of the pelvis associated with restriction of exercise is suggested as a cause of retention of meconium.
4. Some conditions requiring surgical intervention are discussed, and a method of correcting contracted tendons by shoeing and splinting is introduced.
5. The use of hydrocortone in relief of symptoms of joint ill and trauma of the eye is referred to.

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THE SPEAKER'S INTRODUCTION

The Chairman, Mr. R. Moore, called upon Mr. Cosgrove, who said: "Since my paper has been published I have realised its shortcomings and I would have liked very much to have added considerably to it, but as I understand from our Chairman that time is very limited, I am depending on you, ladies and gentlemen, to fill in the gaps during the discussion that follows.

"There is one subject I found great difficulty in describing, and that is the application of the extension splints in contracted tendons. I have now with me two sets of these splints and I shall briefly attempt to demonstrate their application." *(Mr. Cosgrove then gave a practical demonstration of the splints made under his instructions by Messrs Arnold & Sons.)*

The Opener

Mr. S. M. Collins, opening the discussion, said: "I should like to congratulate Mr. Cosgrove on the successful way in which he has covered the problems which confront the veterinary surgeon in private practice when dealing with diseases of the new-born foal. He has given us an excellent paper which obviously is based not only on his extensive reading of the scientific literature but also on his own practical observations. Mr. Cosgrove has presented us with a very wide field for review. Many of the conditions mentioned could, and have, formed the subject matter of several papers. In a paper like this their description has had to be curtailed.

"I have had the privilege of working for a considerable time with our colleagues, Messrs. Reynolds, Leader, Day & Crowhurst at Newmarket where disease of the new-born foal is a special study, and we were in close contact with the research work on foal diseases carried out at the Animal Health Trust's Equine Research Station under Mr. Miller.

"I feel that perhaps the author's opening paragraph, in which he mentions the unhygienic conditions found on many stud farms, is pessimistic and surely exaggerated. Of all domestic animals thoroughbred stock is probably the best housed, fed and cared for. I have not come across many establishments which could be widely criticised for defects in building construction or hygiene, which would have a direct bearing on disease in the young foal. Rather than follow a red herring of this kind, we should recognise the deficiencies in our knowledge of the causes, scientific classification, pathogenesis and rational therapy of these diseases.

"I am glad that the author stresses that the first 14 days of a foal's life are the most critical for its survival. In a statistical study it has been shown that only approximately 50 per cent. of all mares covered produce foals which

survive beyond the early post-natal period. Thirty per cent. is due to primary sterility, 20 per cent. die during the gestation period, or from foal mortality.

"I think it would be better to cover the various conditions under the headings and in the order in which the author has already dealt with them. In passing, I would like to add in addition to the author's remarks on the critical days of a foal's life that probably the greatest single contributory factor to the maintenance of the new-born foal's health is to ensure that the foal gets an adequate quantity of colostrum, the foal's first line of defence against infection. Principally it is recommended that attention be paid to the adequacy of the let-down of the mare at this time and that the foal is suckling properly. The stud groom should be advised of the importance of this. There is, of course, one important exception to the foal getting colostrum, that is, in cases of haemolytic disease.

"The prophylactic dose of penicillin and streptomycin is a little on the low side as the rate of excretion of antibiotics is considerably greater in young foals than in the older horse. It is our usual practice to give one mega unit of each antibiotic. Research work has shown that *Bacterium viscosum-equi* infection in the new-born foal rarely shows itself clinically after 30 hours and it is difficult to infect a foal over 36 hours old with cultures of this organism. In passing, the term "Shigella" is no longer used as a generic name for this organism; its use in this way has been specifically condemned by the Shigella Committee of the International Bacteriological Nomenclature Commission.

"With regard to clinical signs there is one important sign which, from the point of view of differential diagnosis, it is essential to note, namely, the marked reluctance of the sick foal to suckle. This is the very first sign in this disease. In haemolytic disease, on the contrary, the foal shows no loss of appetite and will suck if held to the dam's udder. The sleepy foal will not do this.

"The author mentions the slight rise in temperature. This is an important point as the thermal regulatory mechanism in a young foal, not yet being fully developed, pyrexial responses in acute infectious conditions may not be marked and hence are deceptive. The lethargy which is a marked feature of the disease is essentially a uraemia and the final coma is uraemic. The pulse rate is not an outstanding feature of the disease. Normal foal's pulse rates at this age range between 60 to 90 and will increase with the slightest handling. It is a very remarkable fact that since the availability of streptomycin to practitioners, the mortality rate in this disease has dropped from 33 per cent. to negligible proportions. This is a high tribute to the efficacy of the antibiotic in the treatment of affected foals. In this regard it has been shown that the initial dose of streptomycin should be 2½ to 3 grammes followed by ½ gramme every six hours in order to maintain a sufficient concentration in the tissues. This usually suffices in the majority of cases and it is rarely necessary to use other and more expensive antibiotics. The 250 mg. dose of "Aureomycin" seems to be on the low side and we would recommend 2 grammes intravenously daily for three days. The use of blood is admirable. Its value will be greatly enhanced if the blood is taken from the dam, as research shows that she carries a demonstrable titre of antibodies against the strain of organisms affecting her foal.

"It is interesting to note that the organism *B. viscosum-equi* has been isolated from a foetus in Ireland. This was previously observed by Dimmock at the Kentucky school. These findings are useful inasmuch as they help to settle the controversy of the relative importance of pre-natal or post-natal infection. Generally speaking, septicaemic conditions in foals up to a week old are caused by *B. viscosum-equi;* from the second week onwards, streptococci predominate. This has some bearing on the therapeutic approach inasmuch as streptomycin should be used primarily in the first week and penicillin thereafter. Nowadays we carry a supply of blood culture bottles as it has been found that a rapid differential diagnosis can often be made by taking blood directly from the foal into the culture media and incubating them in our clinical laboratory. This has been the normal practice for the past three years at Newmarket. In streptococcal septicaemia the author has rightly stressed the high temperatures encountered here. It might not be inappropriate to mention that the field of streptococcal infection in horses is a very wide one and consideration of this disease in the foal cannot really be discussed without some reference to the primary source of infection in the mare. The real prophylaxis of this condition in the foal really lies in the clinical and laboratory examination of the mare's genital organs before she is covered, and the application of suitable therapeutic measures. To digress for the moment, it is our usual practice to take cervical swabs from each mare before she is covered. Many of my colleagues will have noticed the previous existence of uterine infection in the dams of their streptococcal foals.

"I disagree with the use of depot preparations of penicillin in acute febrile conditions. The basic principles of penicillin therapy are well known. Briefly, the use of sodium penicillin as distinct from depot penicillin assures the highest level of the antibiotic in the tissues where the organisms reside. The first injection destroys the organisms at the stage of division. An interval of 12 to 24 hours prior to the next injection allows the organism in the resting penicillin-resistant stage to resume multiplication. A further injection of sodium penicillin is then given to eliminate these. This intermittent treatment is continued as long as is necessary. The use of penicillin in acute infections in any other way violates the fundamental principles of penicillin therapy.

"I am afraid I must disagree with regard to the rectal temperature of the foal. We consider the normal range to be between 100° F. and 100.8° F. A temperature of 101.5° F. to 102.5° F. leads one to suspect a febrile condition in a foal.

"With regard to accompanying infections caused by *B. viscosum-equi* and *H. streptococci*, one encounters frequently polyarthritis characterised by serous or purulent synovitis of one or other of the diarthrodial joints of the limbs. This, of course, is a condition seen in all our adolescent farm animals. While its exact pathogenesis is unknown, it has been suggested that a possible factor in the production of this lesion is an allergic hypertrophy of the endothelial lining of the lymphatics draining the joint cavity, arising as a result of bacterial infection in the body. This would interfere with the natural drainage from the joint in which synovial fluid accumulates to excess. This latter may or may not become secondarily infected. In *B. viscosum-equi* septicaemia, infection of the joints commonly occurs, whereas in *H. streptococci* and erysipelothrix infections it is often difficult to find the organism in the joints. If this is so it would afford a possible explanation of the action of hydrocortisone and allied steroids which would act in clearing the lymphatics through their anti-inflammatory effect on the tissues, once the pyrexia is controlled. We prefer to allow our foals to go out as we think that movement facilitates drainage from the joint.

"Gastro-enteritis in the foal is not a single entity, but according to its causal agent this group of diseases comprise; a number of separate conditions. A whole morning could be taken up in discussing this category of diseases. The chief causes in order of pathogenicity are as follows:—

(a) *Salmonella typhi-murium.*
(b) *Salmonella enteritidis.*
(c) paracolon types.
(d) *Proteus vulgaris.*
(e) *Proteus rettgeri.*
(f) *Proteus morgani.*
(g) Pseudomonas species.
(h) *Clostridium welchii* B. and D.
(i) (possibly) coliform types.

In this respect, none of these latter have been found to belong to any of the recognised pathogenic types of *Bacterium coli* as found in children or calves. Diarrhoea in the new-born foal can also be non-infectious as seen, for example, in association with oestrus in the mare.

"Briefly, the method adopted in our practice for differential diagnosis is to take faecal samples from affected foals for laboratory examination. In the meantime, oral administration and parenteral injection of an antibiotic active against gram-negative intestinal organisms is commenced. At the laboratory identification and sensitivity tests are performed. This is particularly important in the case of Salmonella infection as the presence of this demands the application of very stringent control measures as it is transmissible to human beings. The author has emphasised the necessity in therapeutic measures of not merely removing the cause but the carrying out of replacement therapy in the form of saline

and blood transfusions. These measures are just as important as the use of antibiotics.

"Next comes retention of meconium, a predisposing factor being the pelvic conformation. We consider retention to be primarily due to excessive dehydration of the colon contents and in Newmarket we found the removal of the cause as quickly as possible to be the most satisfactory method of treatment. This was carried out by means of liquid paraffin enemas and the removal of the mass with the Reynolds meconium spoon. This gave the foal immediate relief and was successful in every case. Great care has to be taken in using the spoon because it is possible to damage the delicate rectal lining.

"Haemolytic disease is another condition which, as the author says, has been dealt with adequately elsewhere. The treatment of this condition is now standardised at Newmarket. Six fresh cases a year are transfused with complete success. It is advisable that veterinary surgeons who come across this disease in their practices should advise their clients about the very effective preventive measures which are now available to save mares from giving birth to jaundiced foals. For the substitute feeding of foals, cow's milk made up as recommended by Farrelly & Miller has been found quite adequate.

"With regard to congenital deformities of the limbs, contraction of the flexor tendons is a common condition. I disagree with the author that this is due primarily to contraction of the suspensory ligament. The anatomical connections of this structure are such as to allow it to play only a minor part in this condition. Congenital flexure of the limbs involving the carpus, fetlock and interphalangeal joints, we have found to be due to varying degrees of contraction of the flexor tendons. The method of treatment at Newmarket is the application of gamgee tissue and bandages with tightly bound poroplastic felt. This gave good results except in extreme cases.

"Ruptured bladder in the foal is also quite common and the operation for repair of the bladder devised by Crowhurst has been most successful.

"Barkers and wanders are essentially conditions involving the central nervous system to varying degrees and characterised by continuous convulsive fits in the case of barkers. As in epileptiform syndromes in man the primary cause is unknown. It has, of course, been well established at Newmarket that the condition is certainly not an infectious one and the finding of common organisms in foals dying of this condition represents simply *ante-mortem* invasion of the tissues of a moribund animal. In at least one instance, a mare which herself showed clinical signs of the condition as foal, produced a barking foal. From a point of interest I will mention that one mare produced a barker foal which survived for three weeks; another mare at the same time produced a live foal although the mare had to be destroyed. The latter foal was put up to the first mare as she had a good milk supply and the foal became a barker within two hours after suckling. Transmission experiments with blood and milk from the mare did not produce symptoms in pony foals.

"We have found that Day's method for the correction of entropion is very successful.

"Umbilical abscess: the umbilicus is undoubtedly a common site of abscess formation in the abdominal wall. It has been shown bacteriologically at Newmarket that tetanus intoxication *(sic)* is often the primary focus of infection in these abscesses. We adopt the method of injecting foals with tetanus antitoxin during the first few days of life in areas where this disease is endemic.

"Broken ribs is a common condition in the foal and is one of the hazards of foaling a mare in the standing position. If a foal is presented laterally in the second stage of parturition, the anterior half of the body pulls down the thorax over the medial radial tuberosity on the dependant side. This is particularly the case if the limb is not fully extended and results in fracture of the fourth, fifth and sixth ribs when the thorax comes into contact with the elbow joint. In many cases the ribs unite with callus formation. Occasionally laceration of the lungs and pericardium are followed by pneumonia and asphyxia.

"Because of the unusual length of the umbilical cord in the horse it is occasionally subject to undue torsion following the rotatory movements of the foal at parturition. This can result in a fatal blockage of the blood flow in the organ with subsequent asphyxiation.

"The author did not mention parasitic conditions in the new-born foal, a very big subject. Attention should be given to anthelminthic treatment of mares before foaling and the putting of mares and foals on to clean pastures to reduce the intake of red-worm larvae. During the early days of life when the foal is confined to the loose-box it is more usual to find that infective ascarid eggs can be picked up surprisingly easily by the foal licking the walls and floors of the loose-boxes. To prevent this it is well to have the foaling boxes well washed down and disinfected because owing to the adhesive nature of ascarid eggs it is difficult to remove them. It would not be out of place to mention *Strongyloides westeri* infestation in the young foal; this is not an uncommon cause of scouring in the foal of about three weeks old.

"My thanks are due to my partner, Dr. Brendan T. Farrelly, late of the Equine Research Station, Newmarket, for his help in the preparation of these notes.

The General Discussion

Professor P. A. McGeady (Dublin) thanked Mr. Cosgrove for his excellent paper on this topical subject, which in Ireland was very important, and Mr. Collins for his very able opening.

He agreed with Mr. Cosgrove that the pelvic formation played an important part in retention of the meconium and, as Mr. Collins had said, the dehydration of the colon contents was particularly important. The tendency of some stud managers to hold their foals in for two or three days after parturition predisposed to this condition. The use of liquid paraffin and glycerine—the liquid paraffin both *per os* and *per rectum*—had beneficial results.

A condition he was interested in from the surgical point of view was the rupture of the bladder. The general opinion was that the ruptures were invariably on the dorsal aspect but in the few cases he had last year the break in the bladder was at the middle of the fundus or vertex where the urachus joins it. His opinion was that the cicatrix which forms after birth was not strong enough and gave way when excessive pressure was put upon the bladder. Retention of the meconium seemed to predispose to this condition but he did not have the numbers of cases that Mr. Cosgrove had. He had seen only three, two of them being mare foals, and one had been sent to him by Mr. Cosgrove himself. He had not great experience of barker foals and had only seen a few—all thoroughbred.

With regard to contraction of the tendons, he was inclined to agree with Mr. Collins that this occurred most commonly in the flexor tendons. In his practice days he had seen dozens of these foals and in most of these, the perforans and the perforatus were involved. There was a condition which he later found in yearlings where there was gradual contraction of these tendons which, in time, caused severe knuckling of the fetlock. He performed flexor tenotomy in a couple of these cases with about 50 per cent. success; one did well and the other less well.

Referring to twist of the umbilical cord, Professor McGeady wondered if this condition occurred in horses at all. It was originally put forward as one of the causes of dropsy of the foetal membranes but he had never seen a case of dropsy of the foetal membranes in the horse. If there was twist of the umbilical cord, one would have expected at least a venous congestion of the foetal membranes. It was known the umbilical cord in the horse was very large but, although in theory it could possibly get twisted, in his opinion that very rarely happened in practice.

Dr. W. R. Morton (Queen's University, Belfast) said that, not being a veterinary surgeon but merely an anatomist, he had listened with considerable interest to the speakers. There were one or two points upon which he wondered if there was any information.

He asked if the retention of the meconium was similar to the condition in humans where there was retention of the faeces and dilation of the colon due to defective development of the nerve cells in the lower part of the pelvic colon. Was there any evidence to show that the nerve cells in the foal were absent in the same way as in congenital megacolon in the human new-born?

He was also interested in the drainage of the joints mentioned by Mr. Collins in connection with clearing inflammatory conditions. Professor Davis of St. Thomas's Medical School had done some work on joints and the drainage of injected indian ink particles from the joints of animals. He had found that movement after injection facilitated the clearing of the joints of the injected particles, which appeared to be borne out by Mr. Collins's clinical experience.

Mr. J. C. Taylor (Beccles) said that, as an ordinary country practitioner in England, although speaking at present on his native heath, it was with some trepidation that he entered this contest. He had followed Professor McGeady through college, and when such authorities as Mr. Cosgrove, Mr. Collins and the professor had spoken it ill befitted him perhaps to say anything at all as he was an ordinary farm practitioner.

He lived in the county in which Newmarket was situated, but what the Newmarket people could do with the facilities they had was very different from what had to be done in country practice. The hygiene of the mare and foal at Newmarket was probably the highest in the world, whereas the hygiene of the mare and foal on some farms in Suffolk was probably the lowest. The average Suffolk farmer's idea of a place for a mare was somewhere with an earthen floor, a roof with pre-1914 cobwebs in it and walls which never saw a whitewash brush. A whitewashed and clean farm in his part of the world would probably belong to what they called a "foreigner," a man from the shires or a Scotsman.

On the use of cow's milk in rearing foals, he asked if a foal so reared had ever done any good afterwards; whether it had ever shown stamina or speed or any of the other desirable qualitities one required when putting one's money on it. He had found in the case of cart foals that foals so reared, even if they grew big, were always a little on the tender side. There was a story in Suffolk about a horse which was reared on goat's milk in the hills of Ireland; that, they said, was the reason it was never beaten although it was a delicate animal. He did not profess to know whether the goat's milk had anything to do with it.

In his part of the world they still reared a few horses but there was a terrific prejudice against using a cart mare who had lost her foal to suckle a thoroughbred foal. He asked whether anybody could enlighten him as to whether there was any reason for the opinion "that it would move like a cart-horse because it grew up with a cart-horse." This rather interested him because he was interested in the psychology of these animals, having had a few of them from Newmarket himself.

Regarding the dosage of antibiotics, Mr. Taylor agreed with Mr. Collins. He believed in thorough methods and had never given a foal less than three mega units of penicillin in his life, even when penicillin was a lot dearer than to-day.

Mr. Taylor then made a plea that scientists should make up their minds with regard to nomenclature. He was a general practitioner with a son at present under Professor McGeady's guidance in Dublin and, although he was only a student, half the time Mr. Taylor did not know what he was talking about. Father and son had great difficulty in understanding each other when it came to discussing any bacteriological problem. He wished there could be some standardisation.

He had used a drug called "Intradex" with excellent results in cases where transfusions were necessary, both in bovines and in small animals, and he asked if Mr. Cosgrove or Mr. Collins had ever used it.

He frequently met with pervious urachus in cart foals and said he would like some more information about it.

With regard to "Aureomycin," he generally used about treble the dose recommended.

In his district near the East Coast, where it was partly marshy and partly sandy with clay uplands, tetanus was very deadly. In the area of his practice there had been three cases of human tetanus that year. He never foaled a mare without inoculating both mother and foal. This was routine in his and in several of his neighbours' practices.

He was very interested to find there was agreement that exercise prevented retention of the meconium. He had been in practice in a horse-breeding district for 27 years and had never seen a case of retention of the meconium where a mare had foaled outside, either in a thoroughbred, a cart foal, or a pony.

The only way to get any hygiene on the average Suffolk farm was to get the man to put the foal either in a Dutch barn or a new hut which he was preparing for poultry. These were about the only places which were not infected. He did not think the Newmarket people would think a lot of foaling outside, their animals being more valuable, and, of course, they had trained attendants. Most of the attendants he could find to-day could not even put on a halter as they had been driving tractors since they were about ten years of age and thought the horse and the veterinary surgeon should be put in the museum together!

He asked Mr. Cosgrove and Mr. Collins whether they had ever seen a "barker" or "wanderer" in anything other than a thoroughbred. Mr. Taylor had been asked this question by an Indian veterinary surgeon during the war, and he had never met them in half-breeds, ponies or cart-horses. What had been said about them was apparently largely confined to the thoroughbred.

Mr. A. J. Wright (Macclesfield) thanked Mr. Cosgrove and Mr. Collins for the excellent paper and opening and said how refreshing it was to come to a Congress and hear a discussion on the horse which to many was an almost forgotten thing.

Like Mr. Taylor, he had very little experience of the thoroughbred but he still had a few shires, half-breeds and ponies to attend to.

Saying that everybody realised the importance of it, he asked Mr. Cosgrove and Mr. Collins to give particulars of their present-day anthelmintic treatment of the mare throughout foaling.

With regard to entropion, it was a condition that sometimes occurred in pedigree lambs and he wondered whether they had tried the treatment he used on these lambs; *i.e.*, the application of a local anaesthetic to the eye and massaging or pulling down the lids by the owner periodically for two or three days. He had found it cheap and most useful.

Pervious urachus was a trouble that he found in many foals and, whilst not having done the operation described by the author, he obtained quite good results without operating. Although it might seem drastic, the common treatment he used was three parts of tincture of iodine and one of formalin and with a 5 c.c. syringe inject right into the urachus. Usually one injection, or sometimes two, seemed to clear up the condition very quickly.

Mr. H. M. Wilson (Cupar) said that in Scotland he found it advantageous from every point of view to foal outside. They preferred to brave the weather themselves even when, for instance, removing foetal membranes (except in frightfully wet showers!), rather than bring the mares and foals indoors.

Pervious urachus was a very common condition and, rather than suturing where one was more liable to get secondary infections, he preferred to cauterise the navel with pure phenol. The method was to attach a cone-shaped pledget of cotton-wool to a pair of ordinary dressing forceps, the cotton-wool being soaked in the phenol, and to insert it into the pervious urachus. One such application was usually sufficient, followed for several days by twice-daily applications of simple astringent dusting powder plus, nowadays, an umbrella of antibiotics.

The Reply

Mr. Cosgrove, in replying to the discussion, expressed his gratitude to everyone who had taken part. It was unfortunate that the discussion was curtailed and his replies would have to be extremely brief if the Congress time-table was to be adhered to. He was extremely grateful to Mr. Collins for his eloquent and knowledgeable opening.

Veterinarians in Newmarket had wonderful opportunities due to the proximity and facilities available at the Animal Health Trust's Equine Research Station. He could not give sufficient praise or thanks to Mr. Miller and his team who, he thought, were responsible for up to 90 per cent. of the research and information resulting from it in foal diseases. Ireland was very backward in equine research and it was almost entirely due to these research workers in England that knowledge was in such an advanced state to-day. It

was rather ironical that the benefits of this research had borne fruit in Ireland rather than in England.

With regard to the sleepy foal, Mr. Collins and he did not see eye to eye. He had referred to it as Shigella, which was probably the oldest and best-known name, and in order not to cause any confusion had not applied the new terminology which, of course, was more appropriate. He disagreed entirely with Mr. Collins on the symptoms shown, and emphasised that the foal continued to suck up to the time it was unable to rise from the ground. A feature of the condition was that the foal slept or lay down and did not gain its feet except during the brief periods necessary to suck.

Quite a few speakers had drawn his attention to the low dosage of penicillin and streptomycin, but he emphasised that these were prophylactic doses and not therapeutic. He agreed that stepping it up to 1,000,000 units of penicillin, and 1 gramme of streptomycin could be more beneficial and without risk. He had been delighted to hear Mr. Collins's description of the alternative use of the two salts of penicillin. He had not realised the significance of this method of treatment and considered it one of the most important contributions to the discussion. Mr. Cosgrove said he would again like to emphasise the necessity of maintaining the confidence of foals, which was particularly important when one remembered the number of adult animals to which it was extremely difficult, or occasionally impossible, to administer hypodermic injections. This resentment was in his opinion due to the injection of drugs of an irritant nature.

He was grateful to Mr. Taylor, who was what the Irish called a "great character," and who had the rare gift of speaking on a serious matter in a light-hearted and gay fashion which was a joy to listen to.

Most speakers had considered that the level of hygiene in stud farms was high enough, and while he agreed that such was the case in large centres such as The Curragh and Newmarket, he regretted very much he could not agree where the small and less wealthy studs were concerned.

With reference to Mr. Morton's remarks, Mr. Cosgrove felt he was not qualified to discuss detailed anatomical and histological subjects, but he doubted very much if there could be defective nerve cell development, as retained meconium was of a temporary nature and, with the exceptions described in this paper, recovery was uneventful.

In reply to Professor McGeady's statement that one did not encounter dropsy in the mare, he could not agree as he had seen quite a number of such cases.

Regarding the suggestion that the suspensory ligament was not involved in contraction so frequently seen in foals, a little thought as to the mechanics involved would definitely indicate that some shortening was extremely likely. The benefits of the use of the extension splints over tendon nicking was extremely marked. Mr. Cosgrove said he had not seen or heard of any foal that was operated on by nicking so that the results were sufficiently good to allow it to stand the stress of training as a racehorse. A great number treated by the extension splint method became successful racehorses.

He agreed that cow's milk was unsuitable for foals and considered its fat content far too high to suit a foal's digestion. He himself had discontinued entirely the use of cow's milk for foals and had unfailing success with the use of half-cream human babies' milk marketed in many proprietary forms.

In reply to Mr. Taylor's remarks about the point-to-point horse which had been artificially fed from birth and had subsequently become a "windsucker," he thought that the probable cause of the development of the vice was most likely due to feeding large quantities of milk at long intervals. He thought emphasis should be laid on the necessity for frequent feeding in small quantities in the case of artificially fed foals.

He had used "Intradex" for some considerable time and he considered that this or a similar proprietary preparation were the salines of choice. As these salines were retained by the body due to the slow excretion by the kidneys one should be especially on guard against overloading.

The anthelmintic treatment of the mare mentioned by Mr. Wright (which he had completely omitted from his paper) was very important and could be approached in many ways. In respect of strongyles, the low dosage system in which all animals on a stud farm were given 2 grammes phenothiazine daily for 21 days of the month leaving the remainder of the month free, was very satisfactory. Larger doses of phenothiazine up to 6 grammes daily for five successive days every two to three months also gave good results but was really only suitable on farms not carrying the full complement of equines. Alternatively the daily collection of faeces from paddocks was probably the ideal method but necessitated considerable labour and diligent workers. Ascaris worms, which were the greater problem in young foals, could now be eliminated in the mare prior to foaling and in the young foal by administration of piperazine adipate or lactate.

He agreed with Mr. Wilson that there was no better way of foaling a mare than outside in a field but, of course, in large stud farms it was impracticable and had the added disadvantage that should the mare require veterinary attention at foaling, supervision was difficult, particularly in the hours of darkness.

Pervious urachus had been frequently mentioned in the discussion and Mr. Cosgrove thought it more important to discuss its prevention rather than its treatment. The treatment was straightforward and consisted in the suturing of the patent urachus subsequent to cleansing and disinfecting of the area. Supportive antibiotic treatment hastened healing of the lesion.

Mr. Cosgrove said he was disappointed that little had been said about the "barker" foal. He regretted he could not add further to his brief remarks as stated in his paper. He confirmed, however, that he had not seen a case other than in the thoroughbred foal but emphasised that his practice did not include many half-bred or draught foals.

In his experience, rupture of the lung as a result of fractured rib was quite a significant cause of mortality in the new-born. This usually occurred in mares foaling from a standing position.

Mr. Cosgrove then related his recent experience in calving a giraffe at the Dublin Zoo. Here the giraffe gave delivery from a standing position, the calf falling on to a hard concrete floor from a height of about 10 feet, without any apparent harmful effects.

The use of a spoon in the removal of meconium required a certain amount of skill and no matter how careful or proficient one became in its use, the danger of rupture of the rectum was always present. Consequently, he could never recommend its use, particularly when there was an alternative and safe method of treatment available.

He was surprised that Mr. Collins did not agree with him in respect of normal foal temperatures. Mr. Cosgrove said two years ago he had temperatured and noted a large number of healthy foals and found a variation of up to a degree and a half on many occasions. Exercise, time, feeding and age were taken into account, but no definite conclusion as to normal temperature in any individual was arrived at.

One contributor had asked whether he had any observations to make on the method of injecting liquid paraffin into the eyelid in cases of entropion. Mr. Cosgrove said that the use of liquid paraffin could not be recommended as it remained fluid at body temperature and tended to gravitate away from the site of injection. Paraffins as used in human plastic surgery were suitable, but required special syringes for their introduction. Many methods had been used for the correction of entropion, such as the classical method of removing a small elliptical portion of skin from the eyelid and suturing the free borders, or by nicking the palpebral border of the eyelid. However, that described by Day was the simplest and most convenient.

Survey of Diseases of Dairy Cattle

BY

F. W. WITHERS

Weybridge

Introduction

THIS work owes its inception to the Association. In 1949 the Technical Development Committee of the N.V.M.A. published details of a scheme for the collection of accurate data on the incidence of disease and asked for the co-operation of 200 veterinary surgeons in practice, each willing to select 10 clients to keep records of their herds for a period of one year (*Vet. Rec.* **61,** 614). This trial scheme was not very successful and no definite results have been reported. In 1950 a pilot survey of dairy herds in Surrey and Berkshire was commenced by the Veterinary Laboratory, Weybridge on the lines proposed by the Association. This was extended to Wiltshire in 1951. The work has since been developed and expanded further and valuable experience gained in the technique and methods of conducting such surveys.

It is proposed in this paper to describe these developments and to discuss the value of the results achieved.

Herd Sampling

A weakness of the original scheme was the *selection* by veterinary surgeons of the herds to be surveyed. Although the selected herds were to be of all types to ensure data "from a cross-section up and down the country," it is impossible in practice to obtain samples in this way that are statistically unbiased. It was appreciated from the beginning that reliable and representative data could only be obtained from random samples.

During the first three years (1950-51 to 1952-53 inclusive) the recruitment of five per cent. samples of the dairy herds in the counties of Surrey, Berkshire and Wiltshire was the objective. The Surrey sample was based on the original Weybridge mastitis survey and those for the other counties were obtained by direct sampling on a 1 in 20 basis of the lists of herds in the Animal Health Divisional offices. Owing to the poor co-operation of non-designated herds and the inclusion in the survey of a number of herds (mostly attested) which had been selected by veterinary surgeons under the N.V.M.A. scheme, there was a tendency from the beginning for the samples to be overweighted in favour of the designated herds. This was accentuated in succeeding years. A large proportion of the designated herds was willing to give continued co-operation, whereas an increasing number of non-designated herds dropped out.

In 1952 Mr. F. B. Leech of the Department of Statistics, Rothamsted Experimental Station was consulted and he has since undertaken the work of sampling. He recommended that fresh random samples of herds should be drawn each year, whilst a small number (25 to 30) of the original herds should be retained for several years to give an indication of seasonal variations in disease incidence. It was decided to retain the original samples in Surrey and Berkshire for this purpose and no new herds in these counties have been recruited. The system of fresh annual sampling was to be applied in Wiltshire and in any new areas to which the survey might be extended.

The sampling procedure adopted for 1953-54 and subsequently has been the following. Separate preliminary random samples of the designated and non-designated herds* have been drawn by the Milk Marketing Board from its lists of registered milk producers. The herds in these samples have been classified according to the numbers of dairy cows they contained and suitable sampling fractions applied to the different size-groups. The fractions have been chosen to give the numbers of herds required in the final samples, and it has generally been the practice to omit the smallest herds when they did not constitute a sizable proportion of the cattle population. Usually, relatively more of the larger herds have been included because these are less frequent and would often not be adequately represented if a single fraction were used. Further, though not very numerous, they usually contain quite a large proportion of the cattle population.

By drawing samples in this way the results in each stratum can be multiplied by the reciprocals of the relevant fractions to provide estimates of the disease incidence in the sampling areas.

In some cases samples have been drawn from whole counties and in others, particular dairying areas have been selected according to the distribution of farming types.

The sizes of the samples have primarily depended on the number of herds that could be adequately visited and recorded by the staff available. On an average it has been found that one person could deal with a sample of 100 to 150 herds.

Recording Technique

The information for his herd is recorded by the farmer or stockman on a large card (the Farmer's Card) which is basically Form 4 of the original N.V.M.A. scheme. At the outset this form was

*Since the Accredited Herds Scheme came to an end on 30.9.54, only Attested and/or TT-licensed herds are "Designated."

actually used but some modifications have been introduced as the result of field experience. At present two cards of this type are in use, one for 25 cows and young stock and another for 40 cows, so that one, two or more cards can be supplied according to the size of a particular herd. On these cards are recorded the names or numbers of the cows with their calving and service or insemination dates, and details of deaths, disposals and sickness during the survey year. The numbers of young stock and any sickness among them are also noted. These cards normally suffice for one year and the survey year starts on October 1st to coincide with the milk recording year.

For the first two years of the pilot survey, plain cards were used for the transcription of the data recorded on the Farmers' Cards. This necessitated hand sorting and analysis at the end of each year and was unsuited to work on a larger scale. In 1952 two Cope-Chat cards were designed for this purpose, a Farm Card and an Individual Card. The first is used for recording general data relating to the herd as a whole, including the numbers of stock, the breeds of the cows, the fertility status indicated by the numbers of services or inseminations required for the year's calvings, the numbers of dry cows in each month and information on pasture, milking technique, use of S.19 vaccine, etc. On the reverse of this card is a summary of the calvings under months and lactation numbers.

The Individual Card is used for any cow or served heifer that dies, is disposed of or is sick during the survey year, only one card being made out for a given animal irrespective of the number of attacks of disease during the year. Particulars of age, breed, last calving date and subsequent service dates, date of death or disposal with cause, and the destination of the carcase or animal are entered. On the reverse of the card are noted details of each attack of sickness with dates of onset, duration and outcome.

Visits are paid to the herds at approximately quarterly intervals. In practice, five visits are made to each herd keeping records for one year : a recruiting visit before the commencement of the year, three visits within the survey year and one after the close of the year. At the visits within the survey year the numbers of stock are recorded in the categories enumerated in the schedule of stock and these are averaged for each herd for the survey year. The total average stock of each category for all herds in the sample gives the population on which disposal and disease incidences are calculated.

Commencing with the samples for 1952-53 and the use of Cope-Chat cards, the data have been analysed by the Statistical Department of Rothamsted Experimental Station.

Results achieved

The progress of the pilot survey and the general results during the first two years up to September 30th, 1952 have already been described (*Vet. Rec.* **67**, 605). It is hoped that the results for the following two years (1952-53 and 1953-54) will be published in the near future.

It is emphasised that the data so far collected are, with certain reservations, only applicable to the areas surveyed and for the periods covered. The problem of estimating disease loss for the country as a whole, still remains. This will be referred to in the discussion at the end of this paper.

Development of the work

As already stated the survey was started in Surrey and Berkshire in 1950 and extended to Wiltshire in 1951. A grant by the Agricultural Research Council and subsequent assistance from Conditional Aid funds* have permitted extension to Devonshire (1953) and to Shropshire, Ayrshire and Lanarkshire (1954). The work in Scotland is being carried out in co-operation with the Veterinary Department of the West of Scotland Agricultural College, Auchincruive, Ayr.

The following table shows the numbers of herds which have taken part in the survey during the five years. The figures for 1950-51 to 1953-54 inclusive are the actual numbers which have supplied information. Those for the current year are the estimated numbers expected to complete records for the year ending September 30th, 1955.

Counties	Number of Herds				
	1950-51	1951-52	1952-53	1953-54	1954 55
Surrey	58	55	36	24	23
Berkshire	64	58	41	31	27
Wiltshire	—	50	93	157	130
Devonshire	—	—	—	94	120
Shropshire	—	—	—	—	140
Ayr/Lanarkshire	—	—	—	—	100
Totals	122	163	170	306	540

Practical difficulties

As already pointed out a fundamental difficulty is to obtain full co-operation. The degree has varied from 70 to 90 per cent. in the samples so far surveyed. It has been lowest among non-designated herds. In Wiltshire, where experience has been the most extensive, it is the larger non-designated herds that have failed to co-operate. In areas where progress towards attestation has been rapid during the last few years, it has often happened that herds drawn as non-designated in the samples, have become attested or are in the process of attestation by the time they are first visited. They may refuse to co-operate because changes are taking place in the composition of the herd and record-keeping is difficult. If such herds have already become attested and the owners are willing to keep records, the balance of the sample is upset. In the case of herds that are still non-designated at the time of recruitment but obtain T.T. licences or become attested during the survey year, one can only note the date of change of status and regard them as being of the designations

* Assistance received under the Conditional Aid Scheme for the use of counterpart funds derived from United States Economic Aid.

which they held for the greater part of the year. A number of those drawn in samples are "flying" herds and these introduce a difficulty in that a large turnover of cows is involved to maintain a moderate-sized but constantly changing milking herd. There is thus an abnormal number of disposals and particulars of individual animals are often not shown. In these herds there is a tendency to cull animals which are sick and the details and outcome are not usually ascertainable or the information is unreliable.

There are naturally inevitable refusals to co-operate on grounds of overwork, shortage of staff or labour troubles, ill-health and various private reasons. In some cases there have been refusals by the owners of large pedigree and attested herds which rear stock for sale apparently from reluctance to record in writing troubles which may be experienced. This has occurred in Scotland in areas 100 per cent. attested, where difficulties with non-designated herds do not arise.

On the whole the response is to be regarded as good as the farmer gets no material return for the trouble of extra clerical work and the scheme is voluntary.

Undoubtedly the ideal herd for this type of survey is the self-contained and attested herd, in which, apart from normal wastage through deaths, old age, poor yield or infertility, the cows remain in the herd for their normal life-span and wastage is made good by young stock reared on the farm. In such herds it is comparatively easy to record wastage and disease accurately, and for the most part, owners are keen to keep records for several years. Unless it can be shown however, that these herds give a picture of disease incidence that is the same as that for other types in the area, the results cannot be used to estimate total loss or average incidence.

In many cases, if initial reluctance to keep written records can be overcome, the value of such a record to the farmer himself becomes apparent, and there is willingness, even enthusiasm, to continue for a period of years.

The standards of record keeping vary very greatly, from the almost perfect records kept in some pedigree herds to those that are primitive in the extreme. It is, however, very desirable to secure the maximum of information, *i.e.*, the co-operation of as large a proportion of the sample as possible, provided it is reasonably reliable. Much can be done by questioning in the case of sketchy and incomplete written records. Willingness to co-operate is therefore to be encouraged and no arbitrary standard of efficiency has been laid down as a minimum for inclusion.

Discussion

Since October 1st, 1953, using a combination of annual random sampling and Cope-Chat card recording, and with considerable extension of the areas under survey, a start has been made on the collection of information the statistical analysis of which has only just commenced. It is hoped that much valuable knowledge will result from a detailed examination of this material. The ways in which it can be analysed are almost unlimited.

It has been pointed out, however, that the results are only applicable to particular areas and years. The bigger problem of disease loss in the country as a whole has yet to be tackled. This involves the determination of the smallest sample of herds that will give reliable data, which in turn requires an answer to the question: "What is the least common disease in which we are interested? It is apparent that accurate information on a disease affecting a very small proportion of the population needs a much larger sample than is necessary in the case of one with a high incidence. I am told that about 30 cases in a given year is the smallest number required for reasonably accurate analysis. On this basis a sample containing a population of 30,000 cows, or say 1,000 dairy herds, might be expected to give useful data on diseases with as low an incidence as 0.1 per cent. It might be possible to apply the technique outlined in this paper to small samples averaging perhaps 12 herds in every county. The field work involved would be comparatively light and need only occupy a small proportion of the time of a veterinary officer in each division. The drawing of the samples however, would require a great deal of care and thought, and a very high degree of co-operation by the sample herds would be essential. This is a subject which might well be given careful consideration.

Another aspect of the work on which useful information will be available as a greater volume of data from a wider field is obtained, is the relationship of disease to the various environmental factors such as locality, climate, soil, methods of management and the effects of preventive vaccination and treatment.

An objection which has been levelled at this method of obtaining data on disease, is that it is the herd owner or stockman who is primarily responsible for the information recorded and that errors due to lack of professional knowledge and the personal factor are likely to be introduced. This is not such an important objection in the case of dairy cattle as it would be for other classes of livestock, as an experienced stockman is usually well acquainted with the diseases of dairy cows, but it needs to be kept in mind. The assistance of veterinary surgeons in practice in making appropriate entries on the record cards is sought, and encouragement to send suitable material to Veterinary Investigation Centres where there is difficulty in diagnosis or a herd problem exists, is given. The response, however, has not on the whole been what was expected.

In this connection it is important to stress that the team engaged on survey work of this kind should be members of the profession. The confidence of co-operating herd owners and the necessary knowledge and experience to question those keeping the records and to make accurate assessments, are essential. Regular personal visits to the farms are also a *sine qua non*; few farmers will send information by post and fairly frequent personal contacts are necessary to obtain the data needed.

Summary

An account is given of a survey of diseases of dairy cattle which was started in Surrey and Berkshire in 1950 with about 120 herds and has since been extended to Wiltshire, Devonshire, Shropshire, Ayrshire and Lanarkshire with over 500 herds participating. The development of the work during the past five years and the sampling and recording techniques at present used are described. The results so far achieved and the limitations of data collected in this manner are discussed. The possibility of applying the methods described to the wider problem of estimating disease loss for the country as a whole is considered.

Acknowledgments.—I wish to thank Dr. A. W. Stableforth for his great interest and active support since the inception of this work. I gratefully acknowledge the help received from Mr. F. B. Leech who has advised on the statistical aspect for several years and has undertaken a great deal of the paper work involved. I also record my gratitude to the members of the team whose efforts have made possible the developments of the past two years. Finally, thanks are due to Mr. C. Pringle of the Milk Marketing Board who has kindly prepared the preliminary samples of herds.

Reference

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A Statistical Survey of Veterinary Practice

BY

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IT has been emphasised on several occasions during recent years that the lack of vital statistics is a limiting factor to progress in the field of veterinary medicine. Thus, Sir Thomas Dalling at the 1951 Congress, made "an appeal for the collection of statistical information in all countries on the incidence of the different diseases." Although the profession as a whole is very conscious of this need, relatively few attempts have been made to survey the broad incidence of disease as it affects British livestock. The reasons for this are, of course, obvious. Small surveys, which can be carried through individually are best restricted to one particular disease or to one particular species. A good example of surveys of this type is that by Withers (1952-1953) on mortality rates and disease incidence in calves, and although such surveys are excellent in themselves, they fail to give the broad disease picture.

In an attempt to obtain some data of this type, we have made an analysis of the day book records of three representative veterinary surgeons in private practice over a period of one year. This information was supplemented by details of the farms visited including the numbers of stock carried. The practices are widely dispersed, one in West Scotland, one in North-East England and one in Southern England and are mainly agricultural. The survey covered the year from January 1st—December 31st, 1951.

The technique of analysis, briefly, was to code all items of information, to transfer the coded items on to Powers Samas cards, and the cards could then be sorted by machine.

Details coded on the cards included the following items:—veterinary surgeon, name and address of farmer, with details of acreage, type and number of stock carried; the month, week and day of practitioner's visit, the type and numbers of animals treated and a diagnosis of the condition. The diagnostic code was reasonably well detailed, covering 244 conditions. Details of repeat visits were included but no record of outcome was attempted. The survey was limited to farm work excluding that done on behalf of the Animal Health Division. Small animal practice was not included.

The numbers of animals attended and the case rates per 1,000 animals at risk in the three practices are shown in Table I.

On a few of the farms visited the number of stock carried was not recorded. In calculating the case rates, only data from farms with known populations were used.

The total number of cattle attended in the three practices taken together, was of the order of 10,000, and the ratio of attendance to the four species, namely, cattle : pigs : sheep : horses was 38 : 5 : 3 : 1. The overall case rates indicate that 1,000 cattle will provide about one-third of that number of attendances in a year; with horses the rate falls to give a proportion of about one-quarter, while with pigs and sheep the proportions are only one-fifteenth and one-fiftieth respectively.

TABLE I

Number of animals attended and the case rates per 1,000 animals at risk in the three practices.

Species		Practice (1)	Practice (2)	Practice (3)	Total
Cattle	Number attended	5048	3056	1565	9669
	Rate/1000	389	287	468	358
Sheep	Number attended	349	64	283	696
	Rate/1000	65	2	237	19
Pigs	Number attended	581	85	507	1173
	Rate/1000	66	45	96	66
Horses	Number attended	144	60	47	251
	Rate/1000	385	150	228	255

The numbers of attendances in the three practices showed wide ranges for all species suggesting that sampling in this type of survey is important and that a relatively large number of practices need to be included to eliminate such effects. Nevertheless, the case rates within species, with exception of those for sheep, are more uniform.

Disease Incidence

The diagnostic data were classified under seven categories as follows:—

1. Surgical, including traumatic injury.
2. Obstetrics.
3. Infertility.

4. Non-specific diagnosis, *i.e.*, medical conditions in which diagnosis was mainly on clinical signs.
5. Metabolic and deficiency diseases.
6. Specific medical conditions in which the clinical signs indicate a specific disease due to a living agent.
7. Prophylaxis and other routine procedures.

This classification is used in considering the relative importance of the various conditions encountered within the species.

Cattle

In the three practices 4,355 initial visits were made to cattle during the year, involving treatment of 9,669 animals. Prophylactic and routine treatment accounted for 47.9 per cent. of all conditions treated, followed in importance by the treatment of disease due to living agents with a percentage of 14.8. The non-specific medical conditions accounted for 6.7 per cent.; metabolic and deficiency disease for 5.3 per cent. and miscellaneous diagnosis for 2.0 per cent. Surgery, obstetrics and infertility accounted for 11.6, 6.2 and 5.7 per cent. respectively. Details of incidence of each specific condition cannot be presented in full in a short paper but examination of the data shows that the bulk of each disease category is made up from a relatively small number of conditions. The more important conditions are listed in Table II.

Minor surgical procedures such as dehorning, castration, nose ringing and removal of supernumerary teats, account for two-thirds of the total surgery calculated on the number of animals attended. The treatment of traumatic injury corresponds to a quarter and operative procedures such as teat surgery, rumenotomy and amputation of the digit for 8 per cent. of the total surgery. This 8 per cent. includes 6.8 per cent. for teat operations. Approximately one-third of the treatment of traumatic injury involves the udder or teats. These values illustrate the limited application of major surgical techniques in cattle and they also show the importance of the udder and teats as sites of trauma and operative interference.

More than half the attendance classified as obstetrics consists of the removal of foetal membranes, with dystokia contributing just under one-third of the work under this heading. The remainder is made up of abortion, uterine and vaginal eversion and uterine torsion in that order of prevalence.

Specific infection was diagnosed in less than 1 per cent. of the 539 animals treated for infertility in the year and in over 60 per cent. of the animals no definite cause was specified but it is probably correct to assume that there was no clinical abnormality in the oestrus cycle. Functional infertility was diagnosed in 187 cases, 145 of which were suffering from anoestrus. In the remaining cases the condition was associated with congenital defects of the genitalia.

In the category of disease which may be referred to a living agent, 72 per cent. of the total was associated with bacteria, 27 per cent. with parasites and 1 per cent. with virus infections. Mastitis was easily the most prevalent infective condition attended, being of the same order of incidence as infertility. In general the bacterial conditions encountered appeared to be of a sporadic nature, with an animal/visit ratio near unity, and were of the type which tend to be localised. Thus foot-rot showed a high rate and actinobacillosis and actinomycosis were appreciable in amount. The scheduled diseases played only a small part with, for example, only eight cases of anthrax. Johne's disease was seldom recorded. Of the parasitic diseases, parasitic bronchitis, mange and parasitic gastro-enteritis were of considerable importance and contrast with the bacterial conditions in being of a more epidemic character, with animal/visit ratios of about 4:1.

It is interesting that no cases of cobalt, copper or phosphorus deficiency in cattle were recorded under the category of metabolic and deficiency disease, although teart occurred on one farm in the practice in the south. Milk fever and acetonaemia showed a much greater incidence than hypomagnesaemia, the ratio of attendances being 19 and 11 respectively to 1.

In the non-specific group there were 46 different diagnoses involving all the systems of the body and covering disease in a total of 648 animals. Two-thirds of this total referred to disease of the alimentary and genital systems. In Table II the frequencies of digestive disturbance, enteritis, calf scour and bloat on the one hand and metritis on the other, illustrate the importance of these two systems.

There were a number of diagnoses which it was not possible to classify because of their indefinite nature. They represent a total of nearly 2 per cent. of all conditions treated and include in addition to those shown under miscellaneous diagnoses in Table II, allergy and photosensitisation.

Brucellosis and blackleg vaccination, private tuberculin testing and pregnancy diagnosis accounted for 91 per cent. of all the prophylactic and routine treatments carried out. Calculating on an animal basis this group represented 47.9 per cent. of all conditions treated in cattle. Large numbers of animals, however, are attended per visit for this purpose but even on a visit basis the work represented by this group required more visits than any other group appearing in Table II, with the exception of that headed disease due to living agents.

Enviromental Factors

The technique of coding data on to punched cards simplifies very considerably the study of association of disease with environmental factors. To illustrate the types of analysis which may readily be performed, we include short surveys on the effects of size of farm and of season of year on the incidence of selected diseases.

TABLE II

Major Conditions Attended in Cattle

Condition	% of all conditions treated	No. of initial visits	No. of animals treated	Rate per 1000 animals
SURGERY, OBSTETRICS & INFERTILITY	23.34	1550	2258	83
SURGERY (Total)	11.57	571	1119	42
Dehorning	3.35	76	324	12
Castration	2.85	92	276	10
Removal of Supernumerary Teats	1.21	21	117	4
Wounds and Bruises, Udder and Teats	0.92	88	89	3
Teat Operations	0.79	73	76	3
Wounds and Bruises (not udder, teats or feet)	0.58	55	56	2
Foot Wounds	0.51	47	49	2
Nose Ringing	0.35	22	34	1
Muscular Sprains and Strains	0.26	24	25	1
Remainder	0.75	73	73	4
OBSTETRICS (Total)	6.20	570	600	21
Retained Foetal Membranes	3.42	319	331	12
Dystokia at full term	1.79	173	173	6
Abortion	0.73	53	71	2
Remainder	0.26	25	25	1
INFERTILITY (Total)	5.57	409	539	20
Infertility (cause unspecified)	3.51	256	339	13
Functional Infertility	1.93	143	187	7
Congenital Defects of Genitalia	0.07	7	7	< 0.5
Infectious Infertility	0.06	3	6	< 0.5
MEDICAL CONDITIONS	28.75	2153	2779	134
DISEASES DUE TO LIVING AGENTS (Total)	14.75	1012	1426	53
Mastitis	5.02	438	485	18
Parasitic Bronchitis	2.63	48	254	9
Foot Rot	2.07	172	200	7
Summer Mastitis	0.71	62	69	3
Mange	0.66	8	64	2
Actinobacillosis	0.64	59	62	2
Localized Septic Conditions	0.63	59	61	2
Parasitic Gastro-enteritis	0.61	19	59	2
Actinomycosis	0.26	24	25	1
Remainder	1.52	123	147	7
METABOLIC & DEFICIENCY DISEASES (Total)	5.32	419	514	19
Milk Fever	2.51	243	243	9
Acetonaemia	1.73	123	167	6
Remainder	1.08	53	104	4
NON-SPECIFIC DIAGNOSIS (Total)	6.70	558	648	25
Metritis	1.65	150	160	6
Digestive Disturbance	1.08	92	104	4
Pneumonia	0.44	37	43	2
Enteritis	0.38	32	37	1
Calf Scour	0.27	18	26	1
Bloat	0.26	17	25	1
Remainder	2.62	212	253	10
MISCELLANEOUS DIAGNOSES (Total)	1.98	164	191	7
Pyrexia of Unknown Origin	1.03	76	100	4
Lameness (cause unspecified)	0.23	19	22	1
Recumbency of Unknown Origin	0.20	19	19	1
Urticaria	0.20	19	19	1
Remainder	0.32	31	31	1
PROPHYLACTIC & ROUTINE TREATMENT	47.91	652	4632	172
Brucellosis	16.26	132	1572	58
Tuberculin Testing (Private)	10.14	96	980	36
Blackleg	10.02	94	969	36
Pregnancy Diagnosis	7.29	225	705	26
Remainder	4.20	105	406	16

Size of farm

The farms attended in the three practices have been classified into four groups, *viz.*, those with 10 or fewer dairy cows, those with between 11 and 20, those between 21 and 50 and those carrying more than 50 cows. The incidence per 1,000 cows at risk for a range of conditions, is shown in Table III.

TABLE III

Changes in Disease Incidence with Size of Farm (expressed as rates per 1000 cows at risk).

Condition	Farms with populations of :— 1–10	11–20	21–50	>50
Dystokia	10	13	8	6
Retained foetal membranes	26	26	26	26
Metritis	21	15	10	10
Infertility	53	49	41	19
Mastitis	59	58	43	7
Summer Mastitis	7	7	3	2
Acetonaemia	9	7	4	19
Hypomagnesaemia	2	1	1	1
Milk Fever	20	17	21	30
Foot Rot	13	10	13	19
Number of Cows at Risk	1,632	3,157	3,721	2,298

The rates shown are higher than those of Table II since, here, only the cow populations have been used; in the previous table the rate was calculated from total cattle.

The condition of retained foetal membrane shows no change in rate with herd size. Dystokia, metritis, infertility and mastitis show well marked trends with farm size, being much greater problems in the smaller herds. Acetonaemia and milk fever, on the other hand, appear to be relatively more common in the very big herds. The greater emphasis on efficient management in the large herds and also on high milk yields, may account in part at least, for these trends.

The Effect of Season

To illustrate the effect of season of year on incidence we have chosen the conditions of infertility, mastitis, metabolic disease and foot-rot. These conditions are of general interest and show a high incidence in the three practices.

Treatment of infertility is seen to be at a maximum in the first three months of the year, remains fairly constant between April and August and is minimal between September and December. Non-functional infertility and anoestrus show the same trends but functional infertility, other than anoestrus, and infectious infertility do not show seasonal effects. This variation appears likely to be associated with the season at which the number of calvings is maximal with an additional four months for the infertility to be recognised.

The seasonal trends for retained foetal membranes. and also dystokia, suggest that there are two main calving periods, namely, September to November and January to March. The autumn calving group would seem to be mainly responsible for the high January incidence of infertility.

Mastitis shows high values in December, January and February and remains fairly constant throughout the rest of the year but with a minimum value in June. The peak values are probably accounted for by the greater number of cows in milk during the winter months. Summer mastitis rather surprisingly shows a very small incidence in June and July but increases markedly in August and September.

The three metabolic conditions show well marked seasonal trends. Acetonaemia and hypomagnesaemia are diseases of the winter and early spring months with cows housed and on winter rations, while the milk fever incidence is much more uniform throughout the year, but does show lower than normal values in June, July, August and in December. The milk fever incidence is closely associated with that for retained foetal membranes or dystokia, as is to be expected, in view of the close connection between milk fever and calving.

TABLE IV

THE EFFECT OF SEASON ON INCIDENCE

	Number of animals attended													
	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	N.K.	Total
INFERTILITY (Total)	106	55	66	45	41	43	40	43	18	24	34	24	–	539
Cause unspecified	76	27	38	29	22	26	34	24	14	13	21	15	–	339
Anoestrus	27	24	24	14	15	14	5	6	1	2	7	6	–	145
Other Functional	3	3	4	2	4	3	1	10	3	7	6	3	–	49
Infectious	–	1	–	–	–	–	–	3	–	2	–	–	–	6
Mastitis	70	56	39	33	34	19	34	43	39	31	37	49	1	485
Summer Mastitis	4	1	4	5	3	–	1	28	15	3	–	3	2	69
METABOLIC DISEASE														
Milk Fever	19	23	20	20	24	13	9	13	26	39	27	10	–	243
Acetonaemia	48	31	36	29	4	2	–	–	–	–	5	12	–	167
Hypomagnesaemia	1	1	3	4	3	1	–	–	–	1	–	–	–	14
Foot Rot	25	18	18	8	9	9	10	36	19	25	14	8	1	200

Foot-rot shows no marked seasonal trend, January to March and August to October apparently being the two periods when the condition is most prevalent.

Other Species

It is not possible in the space available to do more than present a summary of the findings in the other three major species, namely, sheep, pigs and horses. This is contained in Table V which shows the data grouped under the headings listed earlier.

Horses

Approximately 40 per cent. of all the conditions treated were included in the non-specific and miscellaneous diagnoses group which contained 100 animals. Colic was diagnosed in 24 cases, lameness in 11 and some condition of the mouth pharynx or teeth in 11 cases. Surgery including trauma was next in order of precedence and this group was composed almost entirely of the treatment of traumatic injury. Of the remaining groups which, taken together, only amounted to approximately a quarter of all disease treated, specific disease was the highest and here parasitic gastro-enteritis and joint ill showed the greatest incidence. In contrast to the position in cattle, prohylaxis and routine procedures in the horse were seldom adopted.

Pigs

Castration was the commonest procedure in the surgery and trauma group. Of the infectious diseases, swine erysipelas accounted for more than one-third of the total and parasitic helminth infestation and mastitis together for more than half the remaining conditions. The residue included necrotic enteritis, swine influenza, mange and swine fever in that order of prevalence. The non-specific category contained a large variety of conditions headed by pyrexia of unknown origin, the numbers of animals involved representing slightly less than a quarter of those in the group. There were six outbreaks of enteritis involving mainly suckling pigs. The post-parturient syndromes of metritis and agalactia was next in order of prevalence followed by rhinitis and pneumonia. The remaining conditions which were of low incidence, included cases of suspected poisoning, bowel oedema and endocarditis. Nutritional anaemia was of importance in the metabolic and deficiency disease group and anoestrus was the most common form of infertility encountered. The number of pigs attended for prophylactic and routine purposes was small compared to cattle and less than 3 per cent. of the total number of visits was for this purpose; immunisation against swine erysipelas formed the major part of this group.

Sheep

The animal/visit ratio in this species is wide. The relative importance of the conditions is therefore more correctly assessed on the visit basis which shows that the conditions due to living agents were the most frequent. In this group pulpy kidney and enterotoxaemia had the highest incidence, followed by parasitic gastro-enteritis. The remainder of this group consisted of various infective conditions including orf, tick pyaemia and joint ill in lambs and foot-rot and scrapie in adult sheep. More than half the visits classified as surgery and trauma referred to castration. The metabolic and deficiency diseases were next in order of prevalence the group being made up almost entirely of hypocalcaemia and pregnancy toxaemia. Prophylaxis mainly involved pulpy kidney and enterotoxaemia vaccinations.

TABLE V

Summary of Conditions Attended in Sheep, Pigs & Horses.

Condition	Sheep			Pigs			Horses		
	% of all conditions	No. of visits	No. of animals	% of all conditions	No. of visits	No. of animals	% of all conditions	No. of visits	No. of animals
Surgery and Trauma	41.3	15	288	27.1	100	318	31.9	80	80
Obstetrics	1.3	9	9	1.3	15	15	3.6	9	9
Infertility	–	–	–	0.5	5	6	0.4	1	1
Conditions due to Living Agents	19.0	25	132	24.1	147	281	7.6	18	19
Metabolic and Deficiency Diseases	3.0	10	21	10.0	14	118	4.0	10	10
Non-specific conditions and Miscellaneous Diagnoses	0.9	6	6	21.4	182	251	39.9	99	100
Prophylactic and Routine Treatments	34.5	8	240	15.7	15	184	12.7	29	32
Totals for Species		73	696		478	1173		246	251

Discussion

The foregoing tables show that the day book records kept by practitioners can be made to yield some information on the broad incidence of

disease and on the extent of prophylactic measures in current use and also on the interaction between certain environmental factors and disease incidence. The results could also be of value in the design or modification of teaching programmes and in indicating lines for research.

The question may be raised of the reliability of the information thus obtained. Quite apart from the limited scale of this survey—the number of practitioners co-operating could probably be increased fairly readily—there remains the question of the degree of bias in the results forthcoming. Farming is a business and in consequence, for economic reasons, not all cases of disease will be brought to the notice of the professional attendant; cases of disease in sheep in particular are likely to remain unreported, and probably also in pigs. The extent of this disturbance is difficult to assess; it probably is not so large as to affect materially the picture with cattle and horses, but may do so with pigs and sheep, *e.g.*, farms surveys may give a more correct picture of total disease incidence but the diagnostic data are likely to be considerably less accurate. It is obvious, therefore, that in order to get the best assessment of the disease position possible a combination of methods will have to be used. Other methods of data collection may not be as susceptible to error as the present one but it is difficult to conceive of any approach which is entirely free from limitations.

There is very little British data of a type similar to the above, available for purposes of comparison. Withers (1952, 1953) compares the incidences of difficult parturition and retention of the placenta per 1,000 pregnancies and also reports the incidence of milk fever in cows. He gives the values 13.8, 20.1 and 28 for the three conditions respectively, per 1,000 pregnancies. Our incidences for these conditions for 1,000 cows at risk were 11, 30 and 24; our data does not allow for the calculation per 1,000 pregnancies. These two sets of values are of the same order.

In the U.S.A., Cornell University publish an annual report showing the frequency distribution of conditions encountered in their ambulatory clinic. Comparison with our results shows a remarkable similarity between the relative frequency of disease conditions.

Thus for cattle the comparative values are as Table below:—

Surgery and trauma are rather different but this is mainly due to the fact that in the Cornell figures, dehorning is 6 per cent. larger than in our series. Many of the values for individual conditions also show marked similarity—retained foetal membranes 3.4 per cent. and 3.2 per cent., ketosis 1.7 per cent. and 1.5 per cent., mastitis 5.7 per cent. and 8.6 per cent., castration 2.8 per cent. and 2.0 per cent. and non-functional infertility 3.5 per cent. and 3.5 per cent. to take a few at random. This would suggest that in spite of its limited scale, our survey has yielded results which may well have a fairly wide general application at least in the field of cattle practice.

PERCENTAGES OF ALL CONDITIONS ENCOUNTERED

	Surgery & Trauma	Obstetrics	Infertility	Metabolic & Deficiency	Medical Specific	Medical not specified	Prophylaxis
Present Survey	11.57	6.20	5.57	5.32	14.75	8.68	47.91
Cornell (1953-54)	18.40	6.0	6.0	3.0	19.30	12.20	35.1

Summary

An analysis of the day book records of three practices is presented. These data, which covered a period of one year, were supplemented by details of the stock carried on farms visited. Estimates of incidence are made for the major diseases in the various species and the scope of this type of survey is further illustrated by examples of the association between the incidence and environment.

Acknowledgments.—We have to acknowledge with gratitude the generous co-operation of the three veterinary surgeons who, for obvious reasons, must remain anonymous.

We would like also to thank Professor A. Robertson for his interest and encouragement in this work.

Our especial thanks are also due to Miss Muriel Latimer for her invaluable technical assistance in this survey.

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Survey of Sheep Diseases

BY

G. B. S. HEATH

PLANNING a survey of sheep diseases to give results of real value is difficult. It is relatively easy to get figures of the incidence of some single diseases, or of the total mortality in flocks, but these statistics are not always the best standard on which to base recommendations for research. The disease which kills, or produces marked clinical symptoms may have less effect on production than the more insidious illness.

Presumably a survey should indicate the actual or potential loss of mutton and wool due to disease, and this appears to be almost impossible. Thus, in the northern counties of England, the most obviously important disease in lowland flocks at present is Nematodiriasis, but it is possible that the less lethal infestation with other worms, including lungworms, may cause greater loss to the farmer than the relatively transient but more spectacular infestation with *Nematodirus*. Losses due to Nematodiriasis are fairly easy to assess, but an estimate of losses due to other worms is difficult. Foot-rot is another example of a disease which can cause heavy losses, but which does not appear in the normal survey results. Assessment of potential loss of mutton due to sub-clinical cobalt deficiency is difficult but may be common. No method has yet been devised completely to overcome the difficulties, but this paper records methods which have been used to attack the problem.

(1) Statistics of Mortality Provided by Farmers

Fifteen farmers distributed over a wide area were provided with notebooks in which they were asked to record all deaths which occurred in their sheep. During the course of a year, each farmer was visited ten times in an attempt to ensure that all deaths had in fact been written down. As a check on this method, the shepherds' notebooks were examined, but the results of the survey were discarded because they were hopelessly inaccurate. When recorded deaths and sales were deducted from sheep present at the beginning of the survey plus lambs born during the survey, the figure produced was so different from the number of sheep actually present that any estimate of losses based on this method was bound to be very inaccurate. Errors of up to 50 per cent. occurred and this was particularly disappointing, because the farmers had been chosen as being reasonably intelligent and co-operative.

Visiting Farmers

This is an unexpectedly time consuming method and, in our hands, produced results of little real value. Even if the farmer were willing to provide accurate information, he frequently did not know the answer to the questions he was asked. Disastrous losses tended to be hidden deliberately or, rarely, exaggerated.

To show that this method could give results of value: a hill shepherd employed to assist in work on tick eradication was required to keep a record of all deaths in his flock, and the record was periodically checked with the stock of sheep actually present. Table I was compiled from his notebook. Many of the lambs died within a few days of birth and it may be argued that they should not appear in the "loss of mutton" column. Since, however, the cost of rearing a lamb on a hill farm is negligible, these lambs were counted as being potential hoggs for purposes of calculation. From this table, it follows that sales of mutton were only 63 per cent. of the possible sales had there been no deaths.

This farm is adjacent to the Ravenglass Veterinary Investigation Laboratory and the shepherd was encouraged to keep his notebook up to date, and to submit as many sheep as possible for *post-mortem* examination. Tables II and III were compiled from his records for 1954 and it will be seen that results of real value are now emerging.

(2) Detailed Statistics from Small Numbers of Farms

This method can produce interesting results but entails close personal supervision by the surveyor. It has only been achieved on the farm on which the Ravenglass V. I. Laboratory is situated and, since this is a fell farm, many of the sheep were found dead on the fell and diagnoses were impossible in these cases. However, some of the figures obtained were of interest. During the five year period covered by the survey, the ewe flock numbered between 300 and 400, and there were 452 deaths in the flock (*i.e.* about 25 per cent. per annum.) Table IV shows the ages at which deaths occurred. Causes of death are shown in Table V. The disastrous winter of 1946-47 explains the high number of deaths classed as being due to accident.

During the same five year period, 714 sheep were sold off the farm, giving a ratio of Sold : Died : : 100 : 64.

Superficial examination of these results shows that deaths in the flock curtailed possible sales of mutton by 39 per cent., but disease probably reduced sales still further. During this period, representative faeces samples were collected from the flock on about 150 occasions each year and they consistently haboured small worm and fluke burdens. Average numbers

TABLE I

Year	Ewe Stock	Losses	Sold	Estimated weight of Mutton sold	Estimated Loss of Mutton due to Death
1938	245	9 hoggs 32 lambs	20 ewes 80 wethers and tup lambs	3,600 lbs.	1,275 lbs.
1939	250	6 hoggs 15 lambs	20 ewes 100 wethers and tup lambs	4,300 lbs.	660 lbs.
1940	250	12 ewes 30 hoggs 35 lambs	20 ewes 110 wethers and tup lambs	4,650 lbs.	2,580 lbs.
1941	250	20 ewes 45 hoggs 60 lambs	10 ewes 23 wethers and tup lambs	1,205 lbs.	3,775 lbs.
1942	275	15 ewes 14 hoggs 60 lambs	40 ewes 76 wethers and tup lambs	4,260 lbs.	2,890 lbs.
1943	273	2 rams 13 ewes 13 hoggs 39 lambs	40 ewes 2 rams 77 wethers and tup lambs	4,395 lbs.	2,245 lbs.
				22,410 lbs.	13,425 lbs.

TABLE II

	1/1/54	31/12/54	Difference	Sold	Died
Rams	12	11	1	—	1 (Blackleg)
Hoggs	180	126	54	46	8 (All from intestinal parasites)

TABLE III

	1/1/54	Lambing	August	31/12/54	Difference	Sold	Died
Ewes	397	390	—	361	36	20	16 (6 accident, 4 undiagnosed, 2 lambing sickness, 1 sturdy, 1 helminthiasis, 1 myiasis, 1 indigestion) 80 ewes were barren
Lambs	—	320	285	—	35	—	35 (18 undiagnosed and stillbirths, 6 blackleg, 5 pulpy kidney, 5 helminthiasis, 1 poisoning)

TABLE IV

Birth to two weeks	120
Two weeks to weaning	145
Adult	187
Total ...	452

TABLE V

Not diagnosed	141
Accident	91
Diseases associated with parasites	96
„ „ „ anaerobic bacteria ...	40
„ „ „ other bacteria	51
Metabolic disorders	16
Not classified	17

of *Trichostrongylus* spp. and fluke eggs per gramme faeces were in the region of 500 and 150 respectively, and Gibson (1955) and Spedding (1952, 1954) have shown that wormy sheep weigh less. Flukes also probably have an adverse effect on the food conversion rate. The farm was heavily tick infested and tick-borne fever bodies were shown on at least one occasion during the year in blood smears from every one of 150 lambs which were examined. A particularly bad outbreak of foot-rot also occurred during this period. It is impossible accurately to determine how much these and other conditions affected production, but it might be true to say that disease lowered sales by some 50 per cent.

(3) Study of Statistics Available from Ministries of Food and Agriculture

If the June returns demanded by the Ministry of Agriculture could be altered to contain a question concerning the number of lambs born, it would be possible to obtain a good over-all picture of the death rate in sheep. At present, it is only possible to deduce the number of sheep which die *after being recorded as having lived*. For instance: over the period 1945-49 inclusive, an average of 4.3 per cent. per annum of the sheep population in England and Wales was not accounted for in the statistical returns from farms and abattoirs. These must be presumed to have died, but the total death roll must have been *very* much heavier, since lambs which were born in March and died before June would not have been recorded at all. If, in future questionnaires, farmers were asked to state "number of lambs born," the mortality in sheep could easily be deduced.

(4) Records of Materials Received at Laboratories

Examinations of these records will undoubtedly yield information on the diseases which kill sheep *and result in their being sent to laboratories*. But some diseases will rarely appear in the laboratory records, although they may occur frequently. For example, cases of death due to dystokia and tick pyaemia (where the disease is endemic) require no laboratory examination for provision of a diagnosis. If this point be realised, however, examination of the laboratory records will give valuable information on the relative importance of diseases which commonly kill sheep.

Mr. W. T. Rowlands has very kindly made available the records of 530 consecutive *post-mortem* examinations on sheep at the veterinary investigation centre at Bangor during the twelve months October 1st, 1953—September 31st, 1954. The causes of death are shown in Table VI.

TABLE VI

A — SHEEP

Enterotoxaemia	109
Mature Fluke	9
Immature Fluke	34
Metabolic Disorders	102
Septic Pneumonia	19
Pregnancy Toxaemia	25
Parasitic Gastro-enteritis	2
Blackleg	2
Black Disease	7
Carbontetrachloride poisoning	13
Gas Gangrene	1
Louping Ill	1
Keratitis	1
Coenuriasis	2
Cobalt deficiency	2
Johne's disease	5
Miscellaneous	24
No diagnosis	16
Total	374

B — LAMBS

Pulpy Kidney	43
Lamb Dysentery	19
Fluke	1
Parasites	23
Coenuriasis	2
Louping Ill	3
Cobalt deficiency	1
Braxy	1
Orf	1
Navel and Joint Ill	15
Metabolic Disorders	1
Carbontetrachloride poisoning	1
Tick Pyaemia	3
Miscellaneous	29
No diagnosis	13
Total	156

(5) Collection of Material from Abattoirs

This may help considerably in assessing the incidence of diseases which may cause unthriftiness. A wealth of material exists in these places and it is unfortunate that so little use is made of the facilities available.

During investigations of fascioliasis, a meat inspector was kind enough to record the number of sheep livers which were condemned because of fluke infestation. Most of these livers were later examined in the laboratory, where they were found to contain an average of 49 adult and 2 young flukes per liver. Between September 3rd, 1948, and April 29th, 1949, 12,148 sheep were killed, and 977 (8 per cent.) of their livers were condemned. Quite apart from any adverse effect which flukes may have had on the health of sheep, they had been responsible for the loss of upwards of 1,500 lbs. of sheep liver from a small area in West Cumberland. (The loss of cattle livers was much greater—43 per cent. or about 16,000 lbs.).

Portions of intestine adjacent to the ileo-caecal valve were taken from 214 abattoir sheep. Scrapings of mucosa from these intestines were stained Ziehl-Neelsen and 46 (21.5 per cent.) contained clumps of acid-fast bacilli indistinguishable from *Mycobacterium johnei*.

Worm counts on 502 abomasa and intestines from the abattoir showed moderate worm infestation to be universal, most sheep carrying about 1,000 to 2,000 worms of various species.

These are just three instances of the ways in which abattoir facilities can be used, but they serve to indicate the potential value of this type of survey.

(6) Collection of Material from Knackers

This has not proved to be of much help in survey work on sheep diseases. A diagnosis by a veterinary surgeon is rarely available, and decomposition tends to occlude lesions before knackers collect the carcases. Even the mortality is not reflected very accurately in the knacker returns, because the farmer generally buries sheep which die in small numbers. This can lend undue importance to epizootics unless limitations of the figures are realised.

Discussion

From the above brief description of survey methods which have been tried, it may be possible to plan future work on surveying sheep diseases.

Before deciding on the survey, it is highly essential that the object of the survey should be fully comprehended. This statement is so obvious that it appears to be redundant, but it is very easy to attempt to investigate too much with one survey. After deciding upon the scope of the work, then it is desirable that a statistician should be invited to help in the planning. The following are the points which may need to be investigated, together with suggestions on methods which may be used.

Total Mortality. The Agricultural Returns (modified as suggested above), together with the records of abattoirs, should give an approximately correct figure. Sellers & Leech (1955) describe a method which would probably be useful for this purpose.

Cause of Mortality. Records of veterinary diagnostic laboratories, supplemented by detailed work on a few representative farms, would probably answer this question. The survey would need to be continued for several years because some diseases vary in their importance from year to year.

Losses Caused by Individual Diseases. If the disease is normally fatal, all sheep which die could be submitted to a laboratory for *post-mortem* examination. If this were done on a truly representative sample of farms, then losses due to the disease could be easily calculated—probably with a fair degree of accuracy.

If the disease does not normally kill (*e.g.* foot-rot and lungworms) it would be very difficult indeed to get an accurate estimate of loss due to the disease. Frequent detailed examination of all sheep on a representative sample of farms, combined with a survey of abattoir material, might help. This might be supplemented by detailed laboratory work to show the difference in food conversion rates between disease sheep and healthy controls.

Comprehensive Disease Surveys. These would be very laborious but not necessarily expensive. They should show :—

(*i*) Total mortality.
(*ii*) Incidence of diseases which may decrease the lamb crop (sterility, abortion, low fecundity).
(*iii*) Incidence of diseases which may be expected to lower production.
(*iv*) Loss of mutton and wool due to poor nutrition.

Detailed records of representative flocks, showing mortality and lambing records would not be difficult. It would be necessary also to study the nutrition of each flock and compare the weights of sheep under different systems of management and feeding. If this could be supplemented by frequent clinical examinations, sufficient information should emerge to permit perhaps not an accurate, but a reasonable approximation of loss due to disease.

In these comprehensive surveys, it would be desirable to seek the help of an economist as well as a statistician. It might be found, for instance, that provision of extra supplementary food would result in heavier lambs; but an economist might find that a less generous diet might yield a bigger profit to the farmer, even though the lambs were not so big.

If these surveys could be carried out efficiently, then research could be planned more intelligently. When a research worker asks for £1,000 to investigate a problem, it sounds rather a lot of money. If, however, he can show that the disease to be investigated costs the industry £10,000 every year, then the request falls into its proper perspective.

Summary

Difficulties associated with comprehensive surveys of sheep diseases are enormous. Results obtained by the use of six different methods are discussed and suggestions are made for planning surveys. Possession of results from reliable surveys may be helpful in planning research.

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Survey of Pig Losses

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Introduction

The following survey was undertaken as part of a general programme set-up under Conditional Aid (U.S.A.), the full complement of which was a study of the prevalence of diseases in livestock in general in Northern Ireland under the following headings :—

1. Liver fluke and parasitological position of cattle and sheep in the poor grazing districts with particular reference to the marginal land areas.
2. Disease position and causes of wastage generally amongst livestock. This will involve the selection of representative herds in each area in order to study the losses, the reason for disposal of animals and the expense involved in replacement.
3. In connection with (2) a survey of the position regarding Johne's disease would be made.
4. Deficiency conditions, particularly in regard to copper and cobalt.

This scheme was commenced in January, 1954, and is covering the two years 1954 and 1955. It relates to a study of disease conditions and mortality rates in cattle, sheep and pigs, and will not be finally completed until July, 1956.

The survey about to be described relates to losses in pigs on Northern Ireland farms during 1954, and is of necessity limited in extent, since, as explained, the complete programme is still in progress. It is thus of the nature of a preliminary and partial report, and a full attempt is not made at this stage to correlate mortality rates with husbandry methods.

Summary of previous work

Information already available concerning losses in pigs relates mainly to pre-weaning losses and has been described, among others, by Menzies-Kitchin (1937), Longwill (1952), Snedecor (1947) and Pullar (1950). Valuable information has been obtained from various pig recording schemes, an average mortality rate in the pre-weaning stage from all these sources being about 20 per cent. Longwill found that some 23 per cent. of piglets of the total number born are lost at birth or within a few hours. Post-weaning losses amounted to 3.6 per cent. of the total pigs born, or 4.7 per cent. expressed as a percentage of pigs weaned. His conservative estimate for the total loss of pigs on New Zealand farms was over half a million pounds sterling. As the sow population of New Zealand is approximately the same as that in Northern Ireland (76,000) an interesting comparison can be made here.

Menzies-Kitchin (1938) showed that out of 13,860 living pigs farrowed from 1,475 litters, an average of 9.4 pigs per litter, 11,340 (7.7 pigs per litter) were weaned. The remainder, representing 18.1 per cent, of the total, died or were killed during the suckling period. He found that the most common cause of loss was reported as "overlain by sow" which accounted for 49 per cent. of the total deaths, excluding stillbirths. This agrees with Longwill's observation that "overlying is by far the largest cause of loss of piglets born with a chance of survival." Menzies-Kitchin also showed that in 1,750 litters there was an increase in the numbers of pigs surviving at six weeks up to litters of 12 pigs, but when there were more than 12 pigs in the litter at birth, the increase in pigs born was discounted by a higher death rate; while in litters of 15 and over, between 40 per cent. and 50 per cent. of the pigs died before they were six weeks of age. An analysis of 250 post-weaning losses showed that "bad doers" accounted for 32.4 per cent. of the total, swine erysipelas 21.6 per cent., paratyphoid 10.4 per cent., and pneumonia 10 per cent.

Snedecor found that 3,017 or 18.3 per cent. of 16,507 pigs farrowed in Iowa during the year following June, 1946, did not survive until weaning, most of them being stillborn or dying within a few hours. Stillborn (14 per cent.), crushed by sow (60 per cent.) and weak and runty (7 per cent.) accounted for the main categories. Among the "older pigs" there were 553 deaths in an average inventory of about 10,000; this is 3.4 per cent. or 4.1 per cent. of those successfully weaned. This represented a loss of $14,240 on the total farm sample of 177. As this was a survey of one per thousand farms, the State figures are $14,240,000 or £5,085,714.

Pullar records the occurrence of stillbirths and nutritional abortion in 10 Victorian herds free from brucellosis and scattered over a considerable area of the State, there being no evidence of any common regional or topographical factor. In all herds the intake of calcium, protein and vitamin A was low. The condition ceased in every herd once the diet was corrected.

Pig Crop Report 1952 cites a loss of 20.2 per cent. pre-weaning mortality for Australia in the spring of 1954 and an average 21.3 per cent. pre-weaning mortality of four spring seasons 1951-54 for this Commonwealth. Queensland had the highest percentage loss (21.4 per cent.) of all the States in spring 1954, and New South Wales the lowest (18.5 per cent.).

Survey Technique

A random sample of 623 farms in Northern Ireland was drawn by the statistical section of the Ministry of Agriculture. Farms containing less than six cattle were excluded on the assumption that there would be too few stock to justify a survey. Every county was included in the sample and the results showed the farms to be distributed as follows:—

The average farm in Northern Ireland is small, being about 30 acres in size.

To date there has been a drop-out of 9.0 per cent. of farms. This has been due to various reasons. In some cases the number of stock has been too

County	No. of Farms	Farms on which pigs were kept
Antrim	128	73
Armagh	79	53
Down	119	81
Fermanagh	85	49
Londonderry	76	55
Tyrone	136	84
Total	623	395

few to justify a survey; many farms had poultry only. In some cases the land was let in conacre; several farmers were unco-operative. At the moment we are collecting data from 395 pig farmers distributed as follows:—

Antrim (73), Armagh (53), Down (81), Fermanagh (49), Londonderry (55) and Tyrone (84).

Before the commencement of the survey, each survey farmer was notified of the nature and scope of the scheme and his co-operation invited. Once we had determined the practising veterinary surgeons concerned, if any, with our farm sample, all were similarly informed and their co-operation asked for in the notification of disease conditions on which they were called upon for consultation. Arrangements were made, when notification was given, for the collection and *post-mortem* examination of casualty animals by the veterinary laboratory at Stormont, a report being sent to the veterinary surgeon concerned.

Information relating to the survey was recorded by each veterinary officer on forms specially drawn up for the purpose. Records were made by each officer in duplicate, the original copy being sent to the veterinary laboratory, which was responsible for co-ordinating the whole survey, and the duplicate retained for use at subsequent visits made, if possible, every three months. Once the data for the two completed years is collected, it will be coded on punched cards, and sorting, etc., carried out on calculating machines.

A Livestock Husbandry Survey is being carried out on cattle and pigs on the same farm sample, and it is intended to integrate both surveys in an attempt to determine the extent and nature of the influence of management on the incidence of disease.

Pig Population

In order to obtain an average number of the different age groups of pigs, the number of each on hand at the beginning and at the end of 1954, was taken and divided by two.

The following Table shows the pig population on the 395 survey farms:—

As the sample is a 1 per cent. one, the total pig population in Northern Ireland as calculated from these farms is as follows:—

Sows	76,400	
Gilts	12,300	
Piglets	260,900	797,000
Weaners and Fatteners ...	536,100	
Boars	1,900	
Total:	887,600	

TABLE I

County	No. of Farms	At Beginning					At End				
		Sows	Gilts	Piglets	W. & F.	Boars	Sows	Gilts	Piglets	W. & F.	Boars
Antrim	73	172	45	674	1,279	4	156	28	491	1,857	5
	Average	164	36	582	1,568	4					
Armagh	53	109	22	397	623	2	88	4	313	583	2
	Average	98	13	355	603	2					
Down	81	223	40	707	1,487	7	186	24	633	1,522	9
	Average	204	32	670	1,504	8					
Fermanagh	49	52	16	111	354	2	39	9	157	302	2
	Average	45	12	134	328	2					
Londonderry	55	96	28	320	463	2	90	3	277	500	3
	Average	93	15	298	481	2					
Tyrone	84	172	25	613	868	1	149	6	527	887	1
	Average	160	15	570	877	1					
Total	395										
Total of Averages		764	123	2,609	5,361	19					

The final statement of the estimated numbers of livestock in Northern Ireland at June 1st, 1954, provided by the Ministry of Agriculture gives the following figures for pigs :—

Sows	76,080	
Gilts	12,690	
Other Pigs :		
5 months and over	154,070	729,330
2 months and under 5 months ...	381,790	
Under 2 months	193,470	
Boars	2,010	
Total :	820,110	

Results

Table II shows the total, by counties, of litters born together with the total number of piglets farrowed, the average number of piglets per sow per year, and the average per litter.

Losses to Weaning

During the period under investigation (1954) the total losses to weaning was 2,478 from 1,231 litters which is an average of 2.0 per litter and 18.2 per cent. of the total number of pigs born. This figure of 18.2 per cent. compares closely with the total pre-weaning losses experienced by Snedecor (1947) in a similar survey in the State of Iowa, which was 18.3 per cent.

A detailed analysis of the causes of losses to weaning in 13,635 piglets born is given in the following table :—

When expressed as a percentage of the total piglets lost to weaning, those overlain amount to 27.4 per cent., stillborn 26.9 per cent. and weakly and crits 16.6 per cent. These three causes of deaths in piglets account for the bulk of the losses and while the subdivision cannot be considered highly accurate in that relatively few farrowings are observed, they represent three categories requiring the attention of veterinary research workers with regard to the large numbers stillborn and better management to reduce the loss caused by overlying. Improved sow nutrition would probably go a long way to reducing the "born weakly and crits" category. Many other factors at present little understood must, however, be involved. Longwill also found that piglets born dead, died at birth and overlain accounted for the main causes of pre-weaning mortality.

It will be noted that there is quite a large category of "given away" under causes of pre-weaning losses. It was found during this programme that in the cases where these were followed up death did eventually

TABLE II

County	No. of Litters	No. of Piglets Born	Average Per Litter	Average Per Sow Per Year
Antrim	274	3,077	11.2	18.8
Armagh	173	1,898	11.0	19.4
Down	341	3,703	10.9	18,2
Fermanagh	73	822	11.3	18.3
Londonderry	140	1,650	11.8	17.7
Tyrone	230	2,485	10.8	15.5
Total :	1,231	13,635	11.0	17.8

Number of Piglets Weaned

Table III gives details of the number of piglets weaned.

It will be apparent from the above Tables I and II that the number of piglets born (ranging from 11.3 to 10.6) and the number weaned per litter (ranging from 9.2 to 8.9) varies less than the average number of litters per sow per year which ranges from 1.8 (Armagh) to 1.4 (Tyrone). These results correspond with the findings of Ballinger (1946) and Longwill (1952). This frequent failure of sows to breed is yet another problem which requires investigation and may be traceable to husbandry errors in the same way as many of the pre-weaning losses undoubtedly are.

TABLE III

County	No. of Litters	Total Pigs Weaned	Av. No. Weaned Per Litter	Av. No. Lost Per Litter	Av. No. of Litters Per Sow Per Year	Av. No. Pigs Weaned Per Sow Per Year
Antrim	274	2,515	9.2	2.0	1.7	15.3
Armagh	173	1,584	9.2	1.8	1.8	16.2
Down	341	3,052	9.0	1.9	1.7	15.0
Fermanagh	73	683	9.4	1.9	1.6	15.2
Londonderry	140	1,276	9.1	2.6	1.5	13.7
Tyrone	230	2,047	8.9	1.9	1.4	12.8
Total :	1,231	11,157	9.1	2.0	1.6	14.6

TABLE IV
Causes of pre-weaning Losses

Cause of Loss	*Number*	*Percentage of Total Piglets Born*
Overlain	679	5.0
Stillborn	666	4.9
Weakly and Crits	411	3.0
Scour and Anaemia	143	1.1
Agalactia in sow	107	0.78
Given away	105	0.77
Savaged by sow	55	0.40
Destroyed	52	0.38
Mastitis in sow	50	0.37
Swine Erysipelas in sow	23	0.17
Pneumonia	15	
Milk Fever in sow	14	
Refusal of Suck by sow	10	
Pneumonia in sow	9	
Hernia	8	
Gut Oedema	7	
Arthritis	7	
Prolapsed Rectum	7	
Drowned	4	
Cleft Palate	3	0.72
Imperforate Anus	3	
"Internal Parasites"	3	
Meningitis	2	
Injuries	1	
Abnormally Large Tongue	1	
Operation for Hernia	1	
Septicaemia following Castration	1	
Intestinal Obstruction	1	
Tetanus	1	
Unknown	89	0.65
Total Losses to Weaning	2,478	18.2

take place in a short period. For this reason and because one cannot be certain that we have been able to obtain the exact total born in each litter, which in many cases is probably more than that recorded, they have been classified under losses. The occurrence of very large litters all the piglets of which cannot be suckled by the sow is of course responsible for this practice in some areas.

Effect of Litter Size and Age of Sow

It was found that the percentage loss increases with the size of the litter and that the number of pigs successfully weaned per litter increases up to the level of 12 piglets born. This has been recorded by Longwill and Menzies-Kitchin who rightly state that under the existing conditions of management, there would appear to be little advantage in obtaining very large litters at birth as this is largely discounted by high pre-weaning mortality.

Lowest losses appear to occur in second and third litters.

Since the predominant breed of pig in Northern Ireland is the Large White type, no attempt was made to assess breed fecundity.

Effect of Season on Mortality

Table V and the accompanying histogram show the total deaths in piglets on a monthly basis. The peak periods are December and January with the lowest death rate (13.7 per cent. of total born) in June. The season appears to have little effect on the litter size, but undoubtedly affects the numbers of piglets surviving at weaning, the adverse effects of cold, wide temperature ranges and lack of sunlight materially increasing the mortality rate.

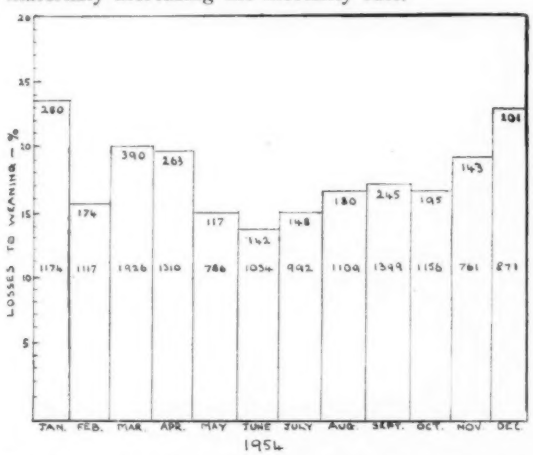

FIG. 6.—Histogram showing the pre-weaning losses on a monthly basis. The upper inset figures relate to actual deaths of piglets and the lower ones the total piglets born.

TABLE V
Showing the number of litters, total piglets born and total deaths to weaning on a monthly basis.

Month	No. of Litters	No. of Piglets Born	Total Deaths to Weaning	%
January	103	1,174	280	23.9
February	103	1,117	174	15.6
March	170	1,926	390	20.2
April	119	1,310	263	20.1
May	69	786	117	14.9
June	97	1,034	142	13.7
July	90	992	148	14.9
August	103	1,109	180	16.2
September	126	1,399	245	17.5
October	106	1,156	195	16.9
November	67	761	143	18.8
December	78	871	201	23.1
Total:	1,231	13,635	2,478	18.2

TABLE VI

County	Total No. of Piglets Born	Total No. of Post-Weaning Deaths	Expressed as % of Piglets Born
Antrim	3,077	49	1.59
Armagh	1,898	11	0.58
Down	3,703	79	2.13
Fermanagh	822	11	1.34
Londonderry	1,650	7	0.42
Tyrone	2,485	25	1.06
Total :	13,635	182	1.33

TABLE VII

Post-weaning Losses—All Counties 1954

Disease	No. of deaths	Expressed as % of total deaths
Gut Oedema	72	39.6
Pneumonia	19	10.4
Gastroenteritis	12	6.6
Meningitis	9	4.9
Poisoning	9	4.9
Swine Erysipelas (acute)	6	3.3
Injuries received fighting	3	1.6
Strangulated hernia	3	1.6
Chronic Swine Erysipelas	2	1.1
Arthritis	2	
Septis Metritis	2	
Volvulus of bowel	2	
Septicaemia (castration)	2	
Septic Arthritis	1	0.55
Tetanus	1	
Intussusception of bowel	1	
Prolapse of rectum	1	
"Rupture"	1	
Post-parturient paresis	1	
Milk Fever	1	
Haemorrhage and shock	1	
"Jaundice"	1	
Nephritis	1	
Unknown	29	15.9
Total :	182	

The above 182 deaths (post-weaning) occurred seasonally as follows :—

Jan.	Feb.	Mar.	April	May	June	
10	13	3	17	25	16	
July	Aug.	Sept.	Oct.	Nov.	Dec.	
11	6	9	11	20	41	= 182

Post-weaning losses

The total number of post-weaning losses on our farm sample was 182 during the year 1954, occurring in each county as follows :—

The causes of post-weaning losses are shown tabulated below :—

The following table shows the number of deaths in each age group in weaners and fatteners and sows and gilts :—

Weaners and fatteners up to four months of age account for 75.3 per cent. of all post-weaning losses and this high mortality relatively soon after weaning indicates a need for more careful management at this vital stage in the pig's life. The large number (72) of deaths caused by gut oedema representing 39.6 per cent. of the total losses is a reminder that this menace is still with us. Next in importance is the pneumonia and gastro-enteritis syndrome as major causes of loss, both of which occur too often, although in many instances not being responsible for death itself.

Total Losses

Table IX details both pre- and post-weaning losses. Total pre-weaning losses are 18.2 per cent. including stillborn pigs. The deaths after weaning are 1.3 per cent. of all pigs born or 1.6 per cent. of pigs weaned. The overall death rate is 19.5 per cent. which is much lower than that recorded by Longwill in New Zealand—27 per cent, and by Smith (1937) who, commenting on work carried out on pig losses by experimental stations in Iowa, Illinois and Indiana, states that "only 60 per cent. of the pig crop reach market".

TABLE VIII

County	Weaners and fatteners					Sows and gilts						
	2 months	3 months	4 months	5 months	6 months and over	1 year	2 years	3 years	4 years	5 years	6 years and over	Total
Antrim ...	2	9	10	18	2	–	3	2	1	2	–	49
Armagh ...	3	1	4	–	–	1	1	–	1	–	–	11
Down ...	11	18	45	1	–	1	1	–	2	–	–	79
Fermanagh ...	–	5	6	–	–	–	–	–	–	–	–	11
Londonderry	2	1	2	–	–	–	–	–	–	2	–	7
Tyrone ...	7	8	3	3	–	–	–	1	2	–	1	25
Total ...	25	42	70	22	2	2	5	3	6	4	1	182

TABLE IX

County	Piglets born	Losses		Total	Expressed as % of piglets born
		To weaning	After weaning		
Antrim	3,077	562	49	611	19·9
Armagh	1,898	314	11	325	17·1
Down	3,703	651	79	730	19·7
Fermanagh	822	139	11	150	18·20
Londonderry	1,650	374	7	381	23·1
Tyrone	2,485	438	25	463	18·6
Grand total	13,635	2,478	182	2,660	19·5
Losses expressed as % of total piglets born		18·2	1·33		
Post-weaning losses as % of total piglets weaned			1·66		

Evaluation of Losses involved

Based on the data obtained from this survey and on the total breeding sow population in Northern Ireland, approximately 76,400, the total losses of piglets up to the stage of weaning amount to 244,480. This has been calculated on a basis of 3.2 piglets lost per sow per year seeing that in our farm sample we had 764 breeding sows with a total pre-weaning loss of 2,478. Working on the basis of a 1 per cent. sample, the total losses would amount to 247,800. Similarly the post-weaning losses would be 18,200, making an overall mortality of 266,000 pigs of all ages.

In monetary value these pigs would amount to :—

247,800 not surviving at weaning @ £2 ... £495,600
18,200 weaners and fatteners, etc. @ £10 ... £182,000

£677,600

Whatever the exact figure is, it is very considerable especially when lack of thrive, and the increased amount of feeding-stuffs necessitated in cases of illness such as gastro-enteritis and virus pneumonia, both of which are very prevalent in Northern Ireland, are taken into consideration.

Summary

A partial and preliminary report of losses in pigs in Northern Ireland during 1954 is given.

Of the total number of piglets born, some 18.2 per cent. never reach the age of weaning which on an average in Northern Ireland is eight weeks, the vast majority succumbing within 48 hours of birth. Most of this loss is caused by piglets being crushed, still-born or weakly, with the anaemia syndrome and conditions in the sow such as agalactia, mastitis, etc., assuming importance.

While post-weaning losses representing 1.3 per cent. of the total piglets born or 1.6 per cent. of those weaned has been shown to be less than recorded in other countries, it is nevertheless still substantial, leaving no room for complacency. Gut oedema has been shown to be the major cause of deaths in this group, most of which (75 per cent. or so) occur in the immediate post-weaning period, which points to a desirability for better management at this particular stage.

Better management and feeding of the sow can help in reducing losses, together with the provision of artificial heat, farrowing pens, guard rails, etc., where these are lacking. In general, the incidence of disease and mortality appear to be relative to the numbers of stock kept.

Nevertheless there are still many aspects associated with this huge loss which are still little understood, among them being the large number of piglets born dead and the ever present menace of bowel oedema. All these require the urgent attention of veterinary research workers.

The number of pigs weaned per litter, litter size, and litters per sow per year compare favourably with those recorded for other countries, so that the line of attack would appear to be an attempt to reduce the above losses by the institution of better management and the investigation of disease conditions at present not understood, rather than trying to increase the fecundity of the sow. In this way the 20 per cent. of pigs which die during suckling and fattening could be materially reduced.

Acknowledgments.—Thanks are due to all those farmers in Northern Ireland who co-operated in this survey. Without their help and interest it would not have been possible.

The valuable assistance given by Dr. F. Yates, F.R.S., and Mr. Leech, B.AGR., M.R.C.V.S., of Rothamsted Experimental Station is acknowledged also.

The Statistical Section, Ministry of Agriculture, was responsible for drawing the sample, and it is desired to thank the staff and Mr. J. Shanks, O.B.E. Veterinary officers of the Ministry of Agriculture were concerned in the collection of data. To them and to our colleagues in practice our grateful thanks are due.

I would especially like to thank Professor H. G. Lamont, O.B.E., D.SC., M.R.C.V.S., Director of Veterinary Research Division, Ministry of Agriculture, not only for his permission to publish this work but for his ever available valuable advice and help.

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THE SPEAKERS' INTRODUCTIONS

The Chairman, Mr. S. R. Bolton said that he first wanted to say how delighted he was to see such a good attendance at the meeting. All the speakers who were going to address them were well known and therefore needed no introduction. It was a pleasure to ask Dr. Withers to begin.

Dr. F. W. Withers (Weybridge): "I should like to take this opportunity of thanking the Organising Committee for inviting me to present a paper on this subject; I regard it as a great honour. I feel I am voicing the feelings of my colleagues, the other essayists, as well as my own, when I say that in presenting these papers we are fully conscious of the limitations of the statistical material we are putting forward; but I do feel that the whole question of vital statistics in veterinary medicine is a subject the need of which has been felt for many years. We have to find some means of collecting as simply and economically as possible data of this kind so that we can get regular and reliable information on the relative importance of the different diseases and the losses they cause.

"I have often been asked 'What are you going to do with all these figures when you have got them?' I believe there is a very good answer to that. I think, firstly that as a profession we ought to know the scale and relative importance of the diseases with which we are commonly dealing. Secondly when we start to collect information in relation to losses in herds we find there are very variable incidences of many diseases. There appears to be a key here for working on the influences of environment, husbandry, and so on. There must be reasons why some animals suffer and others do not suffer at all. I believe that by looking into the husbandry and the environmental sides we can get some indications of the reasons. Thirdly, future research programmes should be based on an accurate knowledge of the relative incidence and importance of the conditions we are investigating.

In presenting this paper, I should like it to be read in conjunction with the article which appeared in THE VETERINARY RECORD of August 13th, on wastage and disease in dairy herds. A further two years' figures are now available, and I had prepared a slide to show the wastage headings and disease groups with the comparable overall incidence figures for four years; but on re-consideration I think that to show a slide of that type momentarily might be rather confusing and could result in erroneous conclusions being drawn with regard to the overall results. I think it is better to publish results in which individual figures can be analysed and commented upon.

"There are, however, a few other slides which I should like to show.

(*A number of slides showing the record cards used and statistical information were then shown*).

"I think that the problem to be solved is to obtain in the most economical and simple way reliable information on diseases and their incidence for the country as a whole. We are all very much open to suggestions because to do this work on a whole-time basis for a limited number of counties or areas is a very expensive job. I feel convinced that if we get together we can devise some techniques by which we can obtain reliable data. We want data *regularly* because the disease picture throughout the country is changing constantly, with the different seasons and with different methods of management. The need is to provide a method which will continually give up-to-date data in this field."

Dr. Grunsell: "On behalf of my co-author Dr. Power, and myself I want to start by saying how very much we appreciate being asked to make this contribution to the symposium on Vital Statistics in Veterinary Medicine. I should like, if I may, to use the short time available to present three aspects of our work. Firstly, I will deal briefly with the method of analysis used in the survey of the three practices, secondly, show the salient findings set out in the paper as printed, and thirdly, compare some of our results with those published last month by Dr. Withers in THE VETERINARY RECORD.

"May I have the first slide please. This slide shows the information available for each of the farms visited by the practitioners. Along the top are shown details of the farm and the population of the farm under species. Each species is further subdivided into class of animal. Down the left hand side appear the dates of the visits. In the next column whether the visit was a first or repeat attendance. Then the species and class of animal: the number of animals involved and where available, the identification of the animal(s). There follows the diagnosis and you will see the treatment shown on the right hand edge of the slide. This latter information was only used to classify the purpose of the visit. I have ringed the entries for one case and would now like to follow the treatment of this entry through the various stages required to transpose the information on to punched cards suitable for mechanical sorting.

Next slide. "Each item of information is given a code number and the data for each case are entered on the transcription sheet shown in this slide. Columns 1-10 deal with information about the farm itself, acreage, occupation of owner and so on. Columns 11-21 provide for the population on the farm and 22 to the bottom are concerned with the case itself; showing the month, the week and the day of the week on which the first visit was made; the species and class of animal attended, the number of animals involved in the visit and the diagnosis. Column 31 is for classification of purpose of visit and Columns 32 on deal with re-visiting.

Next slide. "This simply shows the completed transcription sheet for our imaginary case. The appropriate code number being ringed and written down the margin.

Next slide. "Before the information regarding diagnosis could be coded, each disease condition had to be given a number and this slide shows the diagnostic code which covered some 244 different diseases and conditions.

Next slide. "This shows the card with holes punched in the appropriate number of the column corresponding with the columns shown in the transcription sheet. Thus if we consider the day of the week on which the first visit was made—a Saturday. Column 24 deals with this item and you will see that position 6 in this column is punched out. The numbers along the top are for hand reading of the card.

Next slide. "The punching of the cards is carried out by this machine which is operated by keys like a typewriter, each depression of a key punches a hole in a column and moves the carriage along to the next column on the card.

Next slide. "Once all the cards are punched they are ready for sorting on any of the columns in the machine show in this slide. The cards are fed in at the right hand end of the machine and once set in motion the cards are sorted by needles which sense the holes and feed and count the cards

into the appropriate box. They are the 13 boxes shown along here, the end one being for cards not punched at all in the column. This machine operates at the rate of 40,000 card passages per hour.

"The amount of preparatory work required in recording the information on these cards is considerable, but once the cards are punched, by means of cross and sub-sorting, analysis of the results is greatly facilitated.

Next slide. "These next three slides summarise some of our results.

The data for each species have been grouped under seven headings, namely, surgery, including trauma, obstetrics, infertility, non-specific medical conditions in which diagnosis was on clinical findings, metabolic and deficiency diseases, specific medical conditions due to a living agent and prophylactic or routine visits which included immunization, pregnancy diagnosis, private tuberculin testing and so on. The figures are expressed per 1,000 animals at risk. Some of the points worth noting are the relative frequency with which cattle were attended for all purposes, the highest being for prophylactic and routine purposes. Obviously larger numbers of animals will be involved per visit for this latter purpose, but even on a visit basis, phrophylaxis was second only to specific disease in cattle. On the other hand notice the relative infrequency of visits to sheep and pigs. In the case of horses attendance for surgical purposes and the treatment of non-specific medical conditions was high, while in contrast to cattle prophylaxis and routine treatment was low.

Next slide. "This shows the relation of the incidence of certain diseases with farm size, that is with numbers of cows at risk. Retained placenta shows no variation but the incidence of milk fever and acetonaemia rose with the increase in the number of cows on the farm while the incidence of mastitis and infertility was greater in the smaller herds.

Next slide. "Certain diseases showed a seasonal incidence and here the curves for three diseases are shown. The higher incidence of acetonaemia in winter months is well shown. The changing incidence of infertility, and to a less extent of mastitis, may well be associated with time of calving.

Next slide. "Finally I should like to show a table comparing our figures for disease incidence in cows with those of Dr. Withers. As is to be expected the total sickness figures collected on the farms exceed those determined from the work of the general practitioners. This is due to the fact that there are certain forms of some of the conditions encountered which are never seen by the practitioner, they represent the minor malaise, for example, some difficult calvings, some of the digestive disturbances, some of the mastitis, some of the respiratory conditions. On the other hand in those conditions in which the farmer would be unlikely to seek professional assistance there is close agreement. For example, milk fever, retained placenta and accidents and injuries.

"There is a striking difference in 'other genital disease' in which the practitioner figures give a much higher incidence. This was mainly due to large numbers of cases of infertility.

"In conclusion I should like to suggest that the close similarity between our figures and those obtained by Dr. Withers indicates that the sampling error in both our results is not of a magnitude likely to detract seriously from the general applicability of our findings."

A comparison of the Incidences per cent. of Total Sickness in Cows with Withers (1955) *Vet. Rec.* 67, 605.

Condition	Percentage of Cows at risk showing condition in—		
	Own Survey	Withers Survey	
		1950-1951	1951-1952
Difficult calvings	1.0	2.0	1.6
Stillbirths and abortions ...	0.6	6.8	7.1
Retained afterbirths ...	3.0	3.3	2.5
Milk fever	2.5	2.8	1.6
Other Genital Disease ...	6.2	0.2	0.9
Mastitis (including summer mastitis)	3.2	8.1	7.1
Digestive disturbances including winter scours ...	1.2	5.0	2.2
Foul foot	1.4	3.7	1.4
Accidents and injuries ...	2.0	3.2	2.0
Respiratory affections including husk	0.4	0.6	2.8
Johne's disease	0.2	1.0	0.8
Acetonaemia	1.1	0.8	0.7
Bloat	0.2	0.6	0.7
Grass tetany	0.08	0.1	0.5
Clinical tuberculosis ...	0.06	0.3	0.2
Other sickness	4.6	1.4	1.2
Total sickness	27.8	39.9	33.3

The Chairman said he would now call upon Mr. Heath to present his paper on a survey of sheep diseases.

Mr. G. B. S. Heath (Cumberland): "I have one addition that I should like to make to the paper. I would suggest that in this survey work we should set ourselves a target. It is highly unlikely that any normal flock will ever be free from small losses due to accidents and disease, and when we are estimating losses due to disease it might be wise for us to take this factor into consideration.

In the case of sheep I would suggest that we accept as inevitable a five per cent. loss between the time of birth and the selling of the sheep. We should concentrate on keeping deaths down to this figure.

A survey to show the number of sheep which die every year is urgently needed, and it should be fairly easy to obtain the figures. In that connection, the inevitable five per cent. loss could be disregarded. Surveys to show loss of condition and mortality due to individual conditions are needed, too, and again I do not think great difficulty should be experienced in making them. However, as I have endeavoured to show in the paper, comprehensive surveys for the purpose of giving figures for losses of mutton and wool due to disease and poor feeding would be very difficult indeed to obtain, but it will probably be worth our while trying to get them. Any figures produced would be open to question, but they should be made available if only to stimulate other people in trying to correct them. I think we should bear the point closely in mind that at present in sheep diseases we have little or no information. We have a little information on the number of sheep that die, but information on the number lost due to disease is very scarce.

"One figure that I quoted in the paper, relating to a five-year period on a hill farm, was that for every 100 sheep sold 64 died. The figure of 64 included still-births and lambs which would not in the normal way have been counted by the farmer as having died, but they were potential sheep. The farm was well run and no one was more surprised than the farmer when his attention was drawn to this result. It appears that the hill farmers cultivate a fatalistic attitude towards losses, but I think a survey of losses among hill sheep, while being more difficult to make than a survey of losses among lowland sheep, might possibly be more worth while because I do not believe the average hill shepherd knows how many sheep he does lose."

The Chairman said he would next ask Mr. Gracey to address them on a survey of pig losses in Northern Ireland.

Mr. J. F. Gracey (Belfast): "When I was first asked by the local Organising Committee of the Congress to present a paper on vital statistics in relation to pigs I felt that since our Animal Disease and Livestock Husbandry Surveys are still in progress it would be better to confine oneself to a treatment of mortality rates, since these can be obtained with sufficient accuracy for ordinary purposes, and are probably more extensive than reports on morbidity which are also more difficult to assess. It also seemed a rational way in which to begin a presentation of this type of work.

"No reference has been made in the paper as to how the random sample of 623 farms was drawn. This could be far better explained by Mr. Leech. Briefly, it was carried out as follows.

"One fiftieth of all the farms in the Province were drawn from the 'Enumeration Books' which contain details of all the stock, crops, etc., of every farm in Northern Ireland. This yielded 1,185 farms which were divided into two groups, those containing 0-5 cattle (357) and those with six

or more cattle (828). The former contained only three per cent. of the total cattle population and nine per cent. of the pig population and were discarded because these numbers were considered too small to justify the considerable extra effort that would be required to obtain figures on animal disease. The total number of farms required was of the order of 600, and this was obtained by sub-sampling those containing six or more cattle by deleting a quarter of the farms.

"What was required was a completely random sample of farms having regard to their size and the numbers of stock on them—in actual fact, a small scale model of the total aggregate of farms in Northern Ireland. This random sample, however, has caused a certain amount of consternation among our colleagues in practice and also those responsible for collecting the data. The general feeling has been that the final sample was a poor one in that too many of the farmers were individuals unable for various reasons to supply information of any value. I have been told again and again by practitioners that they have not visited such-and-such a farm for years, and asked, 'Why did you pick so-and-so and not a certain farmer who would be a better proposition as far as survey work is concerned?' The answer is that we are completely in the hands of the statisticians in this matter and we have to abide by their sampling technique, otherwise no statistically accurate conclusions can be drawn from this work.

"The truth is, as Mr. Heath has rightly indicated in his paper, that there are many snags associated with the collection of information of this kind. The average farmer in Northern Ireland, we have found, does not keep adequate records—in fact, most keep none at all—and so virtually all the data has to be given from memory. We were not as fortunate as Dr. Withers, who in his survey of dairy herds was able to leave the herd card he has shown you on the farm to be completed by the farmer. Had we done this I am sure we should have had some new diseases added to the list!

"Even with three-monthly visits, which we considered as an ideal interval, we had to be very persistent in jogging memories. Very often inventories could not be balanced, so that some guessing had to be done. Doubtless among piglets there were occasional losses that were overlooked. On the other hand, we have been very pleased in general with the response—a percentage of 90 co-operating is considered very high. In actual fact, the total number of farmers who completely refused to have anything to do with the Survey was in the region of 25 and in many of these cases there were extenuating circumstances.

"We got the impression in some cases that refusals were in part due to a suspicion that information might fall into the hands of the income tax authorities, this in spite of the fact that at the outset the letter issued by the Permanent Secretary to the Ministry of Agriculture to each survey farmer introducing the scheme made it clear that all data collected would be treated confidentially. Several farmers wanted to know if there was a subsidy for participation in the programme! However, on the whole we were received in a friendly fashion and supplied with the information sought, thought as has been explained, this has, of necessity, been sketchy in parts and has to be viewed in the light that the practitioner was not consulted in many cases, with the result that we had to rely on the farmers' own ideas of diagnosis. At the same time, we had little reason to disagree with their judgement when the cases were discussed with them. At least with the commoner diseases we have found that the average farmer was well acquainted with their symptoms.

"The proper approach to the farmer is fundamental in work of this kind. One had to be very careful in timing visits so as not to clash with sowing and harvesting operations, etc., and although it was our aim to visit at three-monthly intervals, in practice this was not always possible. We found that many were not aware of the existence, for example of the Ministry's Monthly Agricultural Report, advisory leaflets, and service in general. By introducing them to this sphere, to schemes such as the Attested Herds and A.I. and doing our best to develop the farmers' interest, we found that, given an incentive of this kind, co-operation was more easily forthcoming. At the same time we have been very careful not to infringe on the field of the practising veterinary surgeon.

"A few points arise in connection with some figures given in the paper. In discussing Snedecor's work on page two the figure of 533 given for deaths in 'older pigs' should be 553, making a percentage of 3.4 of all pigs farrowed or 4.1 of those weaned successfully. Again in paragraph four of page two, the statement that 'farms of five acres or less were excluded' is incorrect, as has been seen above.

"The manner in which the data relating to our Animal Disease Survey was collected was the only one possible under the circumstances. However, instead of utilising part-time some 40 veterinary officers, I feel that it would be much better to have a smaller staff, say one for each county who, if possible, would be engaged full-time on work of this nature. In this way the data could be standardised more easily.

"There is a need for more *post-mortem* examinations to be carried out, but even when provision was made on notification for the collection of dead animals, it was disappointing to see so few survey farmers avail themselves of this service. Apathy is a difficult problem to fight. I have been amazed at the number of sudden deaths in bovines occurring with no thought whatsoever given to the possibility of anthrax. Not only are we not forming an accurate diagnosis in many cases such as these, but either the farmer does not realise his obligations under the scheduled orders or does not care.

"I have tried to give some impressions of our work and if I have digressed from pigs in general I hope I may be excused. At least we have made a start on survey work and, I must admit, are still learning how to go about the collection of disease statistics in our domestic animals. That there is a need for a clearer picture of the incidence of the commoner diseases and wastage generally amongst livestock, everyone I think is agreed. It seems to me also at this stage that there should be some form of standardised nomenclature so that we all know what the other fellow is referring to. This could be done on the same lines as the W.H.O.'s 'Statistical Classification of Diseases, Injuries and Causes of Death.' I would also suggest that there should be a closer collaboration between those responsible for carrying out these programmes.

'If our claims of leadership in scientific animal husbandry are to stand up under the scrutiny of related fields of science we must develop some feasible system which will tell us with reasonable accuracy what our animal mortality and morbidity rates are and what they are costing us. Failure to do so seems to me to be both unscientific and unrealistic. Also, by knowing them, we could easily pinpoint problems demanding immediate investigation.

"It has been an hour for me to present this paper on pig losses to Congress, and my thanks go to the Organising Committee for their invitation to do so. I hope that in the ensuing discussion we shall learn more about how to reach fulfilment, in the achievement of which the key men are, in my opinion, the farmer himself and his veterinary surgeon. Without their co-operation the value of work of this type is seriously reduced. I have no slides to show, but should anyone like to see the recording forms used in our own work I shall be glad to show them."

The Opener

The Chairman said he would ask Dr. Stableforth to open the discussion, after which others would be able to make their contributions.

Dr. A. W. Stableforth (Director, Ministry of Agriculture and Fisheries Veterinary Laboratory, Weybridge): "I am very glad to have the opportunity of opening this discussion because it is on a very important subject, and takes me back to the old Survey Committee, about 1948, which had a discussion on the importance of collecting data regarding animal disease. That was in Harry Steele-Bodger's time, and it was decided that something ought to be done. It takes me one stage further, to a meeting in his own house— attended by Gould, Hignett, himself, myself and two or three farmers when we discussed the sort of farm card Dr. Withers has shown you.

"It seemed to us that one of the most important things is to have a card of this kind because then the farmer puts

down what occurs at the time it occurs. If it is an abortion or the fact that he has sold a cow it will be correct. If he puts down that a cow has had mastitis it will probably be correct. If a veterinary surgeon is consulted, we encourage the farmer to ask the veterinary surgeon to say what should be put down. There are then the border-line cases in which the farmer gives his own treatment, and those provide the purpose for a visit being made every four months to check what the farmer has got on the card. to check with the veterinary surgeon, or as maybe necessary. I emphasise the importance of the card because if the farmer can be induced to put something down half the battle is won because it is then known that there has been an event about which the farmer can generally give information.

"We all realise we have not enough information on this subject generally, and reliable information is important when one wants to go to the Government to show it is necessary to do something to control disease.

"In the case of notifiable diseases this country has records second to none in both promptitude and completeness, but it is on non-notifiable diseases that information is short. If we want to get to the economic importance of a lot of these diseases we can make a fairly intelligent guess, but we are apt to be shot at if we put out figures which are not sufficiently well based. An attempt was first made to get veterinary surgeons in practice to collect the data, but they were often very busy and in any case there was the selection factor to contend with. Mr. Gracey said that some people bemoan the fact that if a random sample is taken there are a number of farms and people not interested, but it is essential to take a random sample in the first place. It is still open to us ultimately to stratify and say it is known that certain people gave accurate information while the information given by others is inadequate. Those who recorded well may well give one set of answers and those who did not record another set, or the small abstracts may be much alike.

"The purpose of these surveys is to get at the relative importance of these diseases and to know where funds for research should be put and to know what has been done by a certain drug or vaccine. If we had had a sufficiently good random sample in the past we should know that Strain 19 came into the picture at a certain date and had a certain effect. If one considers sulphanilamide in former days in relation to mastitis, no one knows what it did really because we did not know enough about its occurrence and effects before and after the introduction of sulphanilamide.

"I should like to refer to one or two surveys other than those made by the essayists. Mr. Ogden has made a study of farms in Oxfordshire where he did a one per cent. survey over the whole county. Dr. Sellers, a veterinary investigation officer in Leeds, took on another job of surveying sheep in which he took a random sample and asked the farmers a few simple questions. He asked them to fill in a card or to make a return from which he hoped to get a 90 per cent. answer—an important point to the statistician. He just asked how many ewes were born how many animals had dead lambs, how many died of something that looked as if it might be pregnancy toxæmia and how many had a successful lambing. One starts with something like that and pinpoints what seems to be important and can then follow up with another survey on those aspects.

"Mr. Rowlands has done another survey in which he has compared the numbers of sheep on farms in October with those of the following June, *i.e.*, over a period where there are usually very few disposals or losses other than from death. I believe he has shown that in Anglesey there was a loss of 15 per cent. of all the ewes. Something we might persuade the statisticians to do is to put a little more effort into trying to get the real figures for loss of milk and meat. It is extremely important to get the real figures, *i.e.*, not only the numbers of animals which die or are disposed of but the actual loss from these causes and also from various kinds of sickness which cause temporary loss of milk yield or bodily condition. For example at Weybridge, in sheep, Gibson and Taylor were able to show that there was a difference of 30 lbs. between wormy sheep and non-wormy sheep, on good rations. The wormy sheep looked quite good sheep provided the non-wormy sheep were not put beside them. This needs putting into terms of money and the same applies to losses from husk, indigestion and so on.

"Mr. Peck is making a survey of another kind. He is trying to get a knackery survey in the same area where he is getting herd data. He is hoping in that way to check the facts given him by the farmers for disposals.

"With regard to nomenclature raised by an earlier speaker, there is an international nomenclature committee which is trying to standardise the names given to diseases, and it would be as well if we could correlate these things nationally and internationally so that we may discuss in the same terms. I expect Mr. Crawford is here today and he would know something about that.

"To turn to today's papers it is striking that there is so much agreement among the essayists when talking about the same kinds of animals and samples. There are some differences which are quite interesting, but there is a striking likness which makes us believe the figures are not too far from what the right figures must be.

"I should like Dr. Withers to say a little more as to why he thinks that a fresh random sample each year is better than a sample from the same farms. It might be interesting to know what his variations are from year to year on farms.

"I should like to make one point with regard to Johne's disease. Withers gives the figures of 0.8 to 1.0 per cent. of disposals owing to Johne's disease. That is a figure which many people think is too low. It surprises me that it is so low, and it suggests that the farmer is not calling in a veterinary surgeon for Johne's disease but either gets rid of the animal as a complete loss or gets rid of it very early before it has obvious Johne's disease and it is disposed of under some other name. It is one of those few diseases that farmers do not talk about, and that makes it very difficult to get an accurate indication. It is unfortunate because Johne's disease is one of our biggest problems and I think we need to be quite realistic in our approach to it.

"The authors point out that certain diseases are about the same, in large and small herds but that there is a lower rate on large farms for dystokia, mastitis and infertility. I wonder whether it is necessarily a bigger problem on a small farm or whether bigger farms deal with the dystokia themselves. I think the same may apply to mastitis to some extent.

"Mr. Gracey in referring to losses in piglets says that the most important reported cause is overlaying by the sow. I wonder what he would think of the suggestion that that means the young pig is rather sick and cannot get out of the way of the sow quickly enough. Another thing that he has is a category of 'given away'! 'Given away' fits freely with Northern Ireland hospitality, but the next paragraph surprises me because he says most of these pigs die! I should be interested to hear more of the reasons.

"On page five he says that the losses increased with an increase in the size of the litter and the number of pigs successfully weaned per litter increases up to the level of 12 piglets born but not above. I did not think there was a big proportion of litters above that number. He does not say anything about virus pneumonia and I should be interested if he could tell us a little about it."

The General Discussion

Mr. F. B. Leech (Rothamsted Experimental Station) said that he wished to say a few words as a statistician. A factor which had not been dealt with to any great extent in the papers was that of the difficulties in interpreting results. The first difficulty was to decide how reliable were the observations made. One could easily obtain figures for the total number of deaths on farms and one need not hesitate to rely on figures of that sort, but the position was much more difficult when it came to saying how animals had died because there might be differences of opinion between even trained observers. The best practitioners might differ as to why any particular animal had died, so there would always be an amount of data about which one could not really make up one's mind.

Generally speaking, it would cost far too much to collect data about disease and mortality in animals observed by trained field workers and qualified veterinary surgeons and

therefore second-hand information had to be relied upon. Obviously there could not be a trained practitioner stationed at every farm to watch out for every animal going sick. By and large the second-hand information seemed to be good enough when one was dealing with the commoner diseases, but other diseases caused real trouble.

With grass tetany the death might be sudden and the trouble might not be noticed by the farm staff at all. A *post-mortem* examination, if carried out, was not very helpful; and even if the farmer noticed the symptoms and the animal died before professional help was called in, the position was not very much easier. The chances of field workers getting misleading reports varied from one farmer to another.

Consideration might be given to attacking the grass tetany problem by blood analysis. That would tell the incidence of hypomagnesaemia, but that was not related to grass tetany by any constant ratio. It could not be said that the incidence of grass tetany was a standard proportion of that of low blood magnesaemia and virtually nothing was known regarding the statistical relationship. In that connection hypomagnesaemia meant merely low magnesium and grass tetany meant a clinical syndrome. Allcroft had shown there was quite a lot of hypomagnesaemia without any sign of symptoms at all. However, one could set a probable maximum to deaths from grass tetany by adding to the cases which were certainly due to grass tetany cases that could not be determined certainly. From the New Zealand figures of 0.29 per cent. for staggers, milk fever and paralysis and 0.80 per cent. sundry in 1950/51, it could be said with certainty that not more than 1.09 per cent. of the loss from wastage and culling was due to grass tetany. That figure would contain milk fever incidence and a number of deaths that were diagnosed with certainty, so the wastage and culling caused by grass tetany was certainly less than 1 per cent.

That figure might satisfy the administrator and give him all he wanted to know as to the relative importance of the disease, but if one wanted to compare the disease in different areas one would need a more accurate assessment of the incidence. That led to the idea that perhaps the method that Blaxter suggested of bone analysis might possibly be useful.

The second problem in interpretation was finding the most appropriate method of reporting the incidences, particularly those of infectious diseases. The proper method was not as a rule to show the overall incidence per 100 cows. Suppose 2,000 cows were being surveyed on 100 farms and the two largest farms each had 200 cows with winter scours. That would give an incidence of 20 per cent., if the other 98 farms were not affected at all. The 20 per cent. would be a true figure, but it would not convey a very useful overall picture. The appropriate way of dealing with that would be to give two figures, one the percentage of farms affected—2 per cent. in the case quoted—and the percentage of cows affected on those farms—100 per cent. in the case quoted. That might be the method of recording the incidence of disease when some factor of management or environment raised the susceptibility or incidence above the general level. If there was cobalt deficiency on one farm it gave the animals there a higher probability of showing symptoms of that disease than animals on a neighbouring farm where there was no such deficiency.

There were, in fact, very few diseases on farms which lent themselves to random sampling—perhaps dystokia was one of the few—so it seemed that surveys should report two figures, one being the percentage of farms affected, and the other the incidence of infected animals.

With regard to surveys generally, they provided information about population means, the incidence of disease and so on, and showed how disease varied from one part of the population to another. That could be illustrated by means of the following slides:—

First Slide: In the survey Dr. Sellers carried out in Yorkshire, it was decided to divide the county up into a number of areas which represented the different types of farming.

Second Slide: This illustrated some of the differences that occurred in the different areas. There was found to be much more barrenness in the highland areas than in the lowland areas.

Third Slide: This showed the result of an endeavour to associate differences in the incidence of trouble with differences in the management of the animals.

Professor H. G. Lamont (Stormont) said that the subject with which they were dealing was tremendously important and he apologised to the meeting because when the session was fixed it was not realised that the essayists would wish to take up so much time in introducing their papers in so much detail. They were greatly indebted to Dr. Stableforth for pinpointing many things on the question of surveys. Government departments and the farming community generally had a very poor idea of the losses of livestock due not only to disease but also to bad husbandry. The meeting should pass a resolution to go forth to the responsible governments urging them to step up surveys and the provision of far more resources. Each essayist had stressed the inadequacy of the data available. There was a need to educate the farming community in regard to their responsibilities and illustrate to them the importance of losses due to disease and to improper or poor husbandry.

Professor Lamont had the uneasy feeling that when more surveys were carried out in Northern Ireland it would be found that the province lost far more animals through malnutrition than through disease. Surveys must be carried out not for one year on a farm but for five or six years. Some of the figures they were considering gave figures for only one particular year, and the following year there might be a greatly increased loss or no loss at all.

The question of home treatment had been referred to. It was difficult to get round that, but undoubtedly on the farms in Northern Ireland home treatment was the thing. Every farmer was his own veterinary surgeon. There was a great loss in milk and in other respects as a result of home treatment.

It had been mentioned that they were having to deal with second-hand information, and Mr. Leech had rather questioned its reliability. If they wanted to make a success of surveys they had to provide facilities for collecting data concerning the animals on the farms and they should come to terms with the practitioners. They must have the practitioners with them.

Dr. J. I. Taylor (Uganda) said that he hoped that in a discussion largely centred on Great Britain, it would not be considered an impertinence if he spoke on behalf of the veterinarians who are working overseas. They were particularly interested in the assessment of their work, but there was a great temptation to trust to observers other than themselves who might be untrained and inclined to produce entirely erroneous results.

Mr. Gracey mentioned the disease and mortality rates. It was important to bear in mind that what concerned the farmer, whether at home or overseas, was the net economic loss due to losses of production, and not necessarily the mortality rate. On this account, notice must be taken of the management side, and of the total economic losses, and care should be exercised in compiling disease and mortality rates.

Veterinary science was perhaps passing through a phase from the animal disease to the animal health aspect, and for this reason the other side of the picture just mentioned must be borne in mind.

Mr. A. L. Ogden (Berks) said that his interest in vital statistics was of fairly long standing, and an interesting point not fully developed by other speakers was where it was all leading. What was needed from a national and an animal health point of view was regular incidence returns for non-notifiable diseases, something comparable to the Registrar-General's figures or to hospital returns on the human side.

Expensive detailed surveys carried out in particular areas of which he had personal experience, were limited to between one and two hundred herds per veterinary investigator per annum. Even when the method was applied over wider and wider areas, as in the Weybridge surveys, it would be a matter of years before the picture for the whole country became apparent. All such surveys would need to be embraced in a Bureau of Disease Incidence Records before

any regular annual returns could be provided. In that situation it appeared necessary, at least temporarily, to accept some additional method. They must cease to criticise the layman's return, as this was the only hope of obtaining sufficient data during the interim period until more accurate figures became available.

To that end, Mr. Ogden had turned his interest to the Milk Marketing Board, which had a large number of milk recorders already making regular visits to many thousands of herds. By keeping any enquiry to a few simple points he considered useful information could rapidly be obtained. Even the non-veterinarian could distinguish between a cow that had aborted and one that had broken its leg.

In addition to this method, he suggested that the profession should consider the introduction of a "Supplementary List of Notifiable Diseases" for incidence purposes only. When a general practitioner came across a case of a disease listed in the Schedule, he would be under statutory obligation to notify its occurrence to the Ministry. It would be essential to limit the list to a very small number of conditions, but this method combined the advantages of professional basis, as in the Wither's type survey, with the need for a wide returning area.

Finally even the profession's successful services such as the Attested Herds Scheme could be improved upon as a result of the findings of incidence studies of this type. When Mr. Ogden examined the relevant Oxfordshire figures on a parish basis, marked differences were revealed. There were distinct areas which were non-progressive from the point of view of Attestation. On field investigation the reasons could in several cases be pinpointed and some would have been susceptible to treatment had the necessary powers been available. For example, in one village all the farms were in a line down the main street, and their herds intermingled twice daily on their way to milking. Attestation was a question of all or none. If Divisional Officers had powers to institute compulsory tests on such localised foci, the position could have been changed from "none Attested" to "all Attested" in a comparatively short time.

Colonel Cator said that he felt privileged as a guest and a farmer to be allowed to make a contribution to the discussion. It had been said that the farmer played an important part in connection with the interesting papers which had been presented on statistics. A suggestion, for what it was worth, in helping to solve the problem which faced the veterinary profession was that there should be an increase in propaganda aimed towards the farming community. We all knew that the farmer was, as a matter of course, a person who did not like the idea of more forms, but if the importance of surveys and what they really meant to the farmer could be put across successfully, he might look at them with a different attitude.

There was now an organisation which was young compared with the majority of existing organisations—the stockmen's clubs. In Norfolk the stockmen's club membership ran well into four figures. He believed much could be done through the stockmen's clubs, these clubs being composed of the men who actually did the work. If the veterinary profession could get on the right side of the stockmen the rest of the job could be easy.

The Replies

Dr. Withers (Weybridge), in reply, said that knackery work had been referred to, and Mr. Peck had found in Devonshire that one of his three or four knackeries gave him excellent results. It was hoped to superimpose the relative *post-mortem* data from that knackery on to the disposals on account of sickness found in the herd survey.

Another point mentioned was the desirability of prolonging surveys for several years. That was a valid point and it would no doubt be better to recruit people to do the job over a period of years, especially with regard to such things as infertility. In the case of some diseases the incidence appeared to vary greatly from year to year. It was due to the advice of the statisticians, however, that there had been a short-term random sampling.

The point made by Mr. Leech was an interesting one. It would be better in future to give separate figures showing not only the overall incidence of disease but also the percentage of herds affected and the incidence in affected herds. They would have to set about the task of finding out why some herds had a very high incidence while others were practically free of certain diseases.

An effort should be made to procure regular returns, but that was an extremely difficult thing to do. It would be very desirable to have part-time veterinary staff throughout the country collecting figures which were published annually. Unfortunately, however, that would mean putting another job on to people who were busy already and they might look upon it as just "another form to fill in" and not do it very carefully.

Dr. Grunsell in reply, said he thought that most of the points raised by Dr. Stableforth would be clarified when a fuller analysis of the results was published. A feature which had struck one throughout the meeting was that the practitioner was not being given sufficient weight. In actual fact, he held a key position in the whole matter of statistics. Any scheme that went forward should do so with the support and assistance of the general practitioner.

Mr. Gracey in reply, said that overlaying by the sow had been put down in the highest category of pre-weaning losses, but he fully agreed with Dr. Stableforth that other factors undoubtedly entered into the question. It was carefully stated in the paper that it was the most commonly *reported* cause of loss. It had been necessary to rely on what the farmer had said.

With regard to the "given away" category. In the cases that were followed up it was found that death very often did occur, and when it was realised that one could not always be sure of obtaining the exact number of piglets farrowed in each litter since few were personally observed, there was some justification for classifying this category as wastage.

Virus pneumonia had been referred to. It was a condition that was acknowledged as being common in Northern Ireland and was responsible for some 10 per cent. of the total post-weaning deaths.

Although there is a percentage loss with increase in litter size, there is a *net* increase in the number of piglets weaned up to litters of 12. In litters of over 15 piglets, probably 40 to 50 per cent. die before they reach the age of eight weeks.

The Chairman said he was really sorry that the discussion had to be drawn to a close at this stage, but they might recommend that when such sessions were arranged a longer time should be allowed for discussion. They all wished to thank the essayists, Dr. Stableforth, and those who had entered into the general discussion, for providing them with a very enjoyable session.

The Impact of Environment on the Health and Productivity of Pigs

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WITHIN the terms of reference of the above title it is proposed to discuss the results achieved on a large commercial pig farm together with a report on investigations carried out on this farm into certain environmental factors.

The farm in question belonged to Messrs. A. A. McGuckian, Ltd. and had many advantages from our point of view; facilities were available for detailed record keeping, statistical records had been kept since 1935, sufficient numbers of pigs were kept to render any observations made of some significance, and the farm being a strictly commercial enterprise any methods adopted there were always within the scope of practical economics.

The writers would like to record their very real appreciation of the generous and unstinted help accorded them by Messrs. Brian and Gerald McGuckian. Their assistance was always readily available even though on occasions our investigations interfered with the smooth running of their large-scale pig enterprise.

The pig farm was established on its present site at Cloughmills, County Antrim, in 1924 and according to the records the first 18 months were comparatively trouble-free. However, trouble soon appeared and in 1926 when the farm was first visited by a member of the staff of this laboratory (Dr. Lamont) mortality had reached serious proportions. After that visit Dr. Lamont reported that the house for sows and litters was "a very large building, well lighted and very well ventilated." His main impression of the house then (in July) was of coldness and excessive ventilation. During the next 10 years the enterprise kept going under increasing difficulties and by 1936 40 to 50 per cent. of all pigs farrowed died at varying ages after birth. The main disease problems encoun-

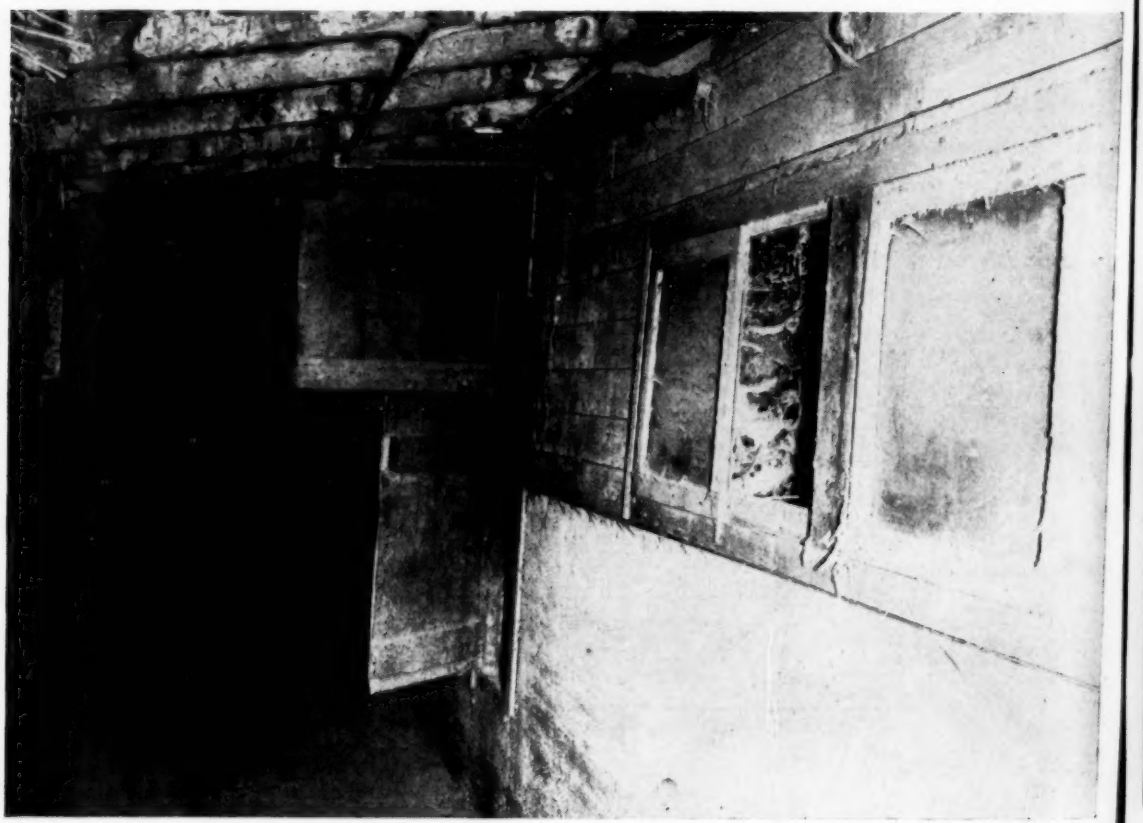


FIG. 1.—Feeding passage showing sliding panel and divided pen door.

tered at this time were pneumonias, enteritis, arthritis and sporadic swine erysipelas. It was realised by this time that the structure of the pig houses was such that the indoor temperature faithfully reflected every change in the weather conditions outside, and it was felt that the often violent changes in the environmental temperature undoubtedly contributed to the existing mortality problem. With a view to controlling these changes an artificial heating plant was installed but this proved expensive to operate and difficult to control and was eventually abandoned with the advent of more rational methods of heat conservation.

An event of considerable importance in the evolution of the present-day methods of pig housing at Cloughmills was a visit by the owners, accompanied by Dr. Lamont and Mr. P. L. Shanks, to Germany in 1937, where the Waldeman system of rearing pigs in insulated huts was seen. The priniciples of insulation and isolation were adopted to suit conditions at Cloughmills and now form the basis of their present-day pig housing. Within the limits of the present paper it will not be possible to describe the modifications used for the different age groups of pigs and it is proposed, therefore, to compare results attained in a pre-war type of house with those achieved in the same house modified in accordance with post-war ideas. In addition certain environmental conditions in this house will be examined in some detail.

The house in which the majority of the present observations were made accommodates about 900 pigs within the weight range 80 to 125 lb. In its original form it has already been described by Shanks in 1942. Modifications were carried out between 1942 and the period covered by the present report (1953-54). The ventilator outlet was doubled providing 6 square inches of outlet per head on the basis of 35 pigs per single pen. The doorway into the feeding passage was divided into top and bottom halves and a sliding panel was let into the wall between the passage and the pen. (See Fig. 1.) The object of all these

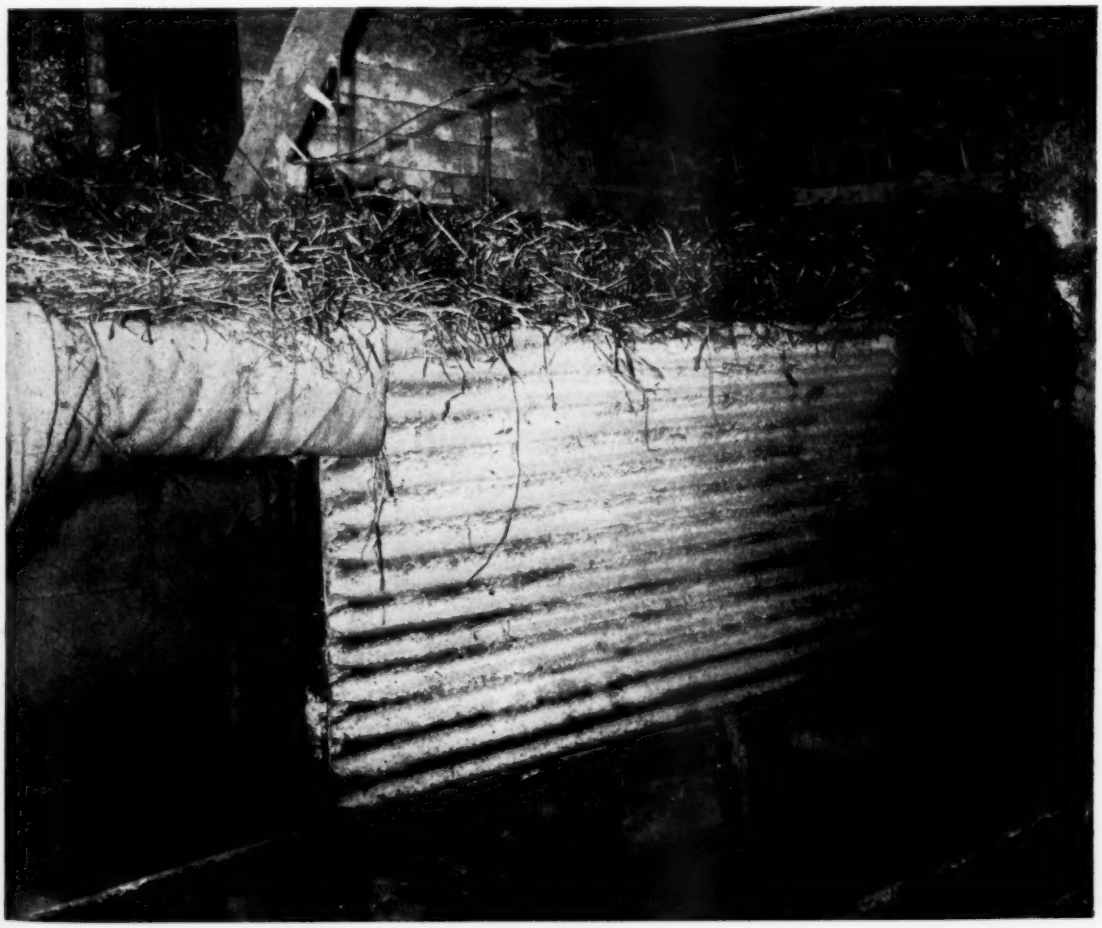


FIG. 2.—Sleeper compartments with common ventilator outlet shaft and adjustment lever

changes was to provide additional ventilation to overcome certain difficulties experienced during periods of very hot weather.

Experiments carried out by Messrs. McGuckian in 1952 suggested that certain additional modifications to the existing house would assist further in reducing morbidity figures. These modifications consisted in the main of providing a low ceiling double compartment insulated sleeper with a controllable ventilator outlet shaft. (See Fig. 2.) The walls of the sleeper consisted of a double thickness of corrugated iron sheets supported on rough timber and set on a 9-inch concrete plinth. The 3-inch space between the corrugated sheets was packed with flax waste. The entrance to the sleeper was draped with sacking. The roof of the sleeper consisted of 6 inches of flax waste on sisal paper and supported by coconut matting and rough timber. The verandah part of the yard was built up to form an enclosed porch. This was provided with a door leading to the outer yard as well as a window and a sliding panel for additional ventilation in warm weather. The owners readily agreed to leave one double pen unaltered to provide a basis for comparing the sleeper type of house with the open type as in use up to 1952. (See Fig. 3.)

With 35 pigs per single pen the houses provided :—

	Total floor area including sleeper space sq. ft.	Sleeper Area sq. ft.	Total Cubic Capacity cu. ft.	Sleeper Capacity cu. ft.	Fixed Outlet Ventilator sq. in.	Movable Outlet Ventilator ex-Sleeper sq. in.
Open Pen	4.8	—	46.5	—	6	—
Sleeper Pen	4.7	2.58	44.78	11.6	3	3

FIG. 3.—Open Pen Layout. Ridge ventilator outlet can be seen in top left hand corner.

By carrying out the present investigation on a successful commercial pig farm it was realised that strict scientific methods might have to give way on occasions to the rigours of economic necessity, nevertheless it was felt that results obtained in such conditions would have an immediate practical application under ordinary farming conditions.

Methods

Observations were made using seven day recording thermo-hygrograph, maximum and minimum thermometers, whirling hygrometer, silver bulb Kata thermometer (temperature range 130 to 125° F.) and a globe thermometer. From this data air temperature, relative humidity, absolute humidity, air velocity, radiant heat, dew point, and effective temperatures were calculated by conventional methods. All measurements except where otherwise stated were taken within a few inches of ground level and as far as possible observations were taken at two or more sites. The importance of these ground level readings for critical evaluation of the environment was amply borne out during the investigation. The sites at which the readings were obtained are shown in Figure 4 (a) and (b).

A maximum and minimum thermometer was attached to each thermo-hygrograph by means of wire hooks and elastic bands and both instruments

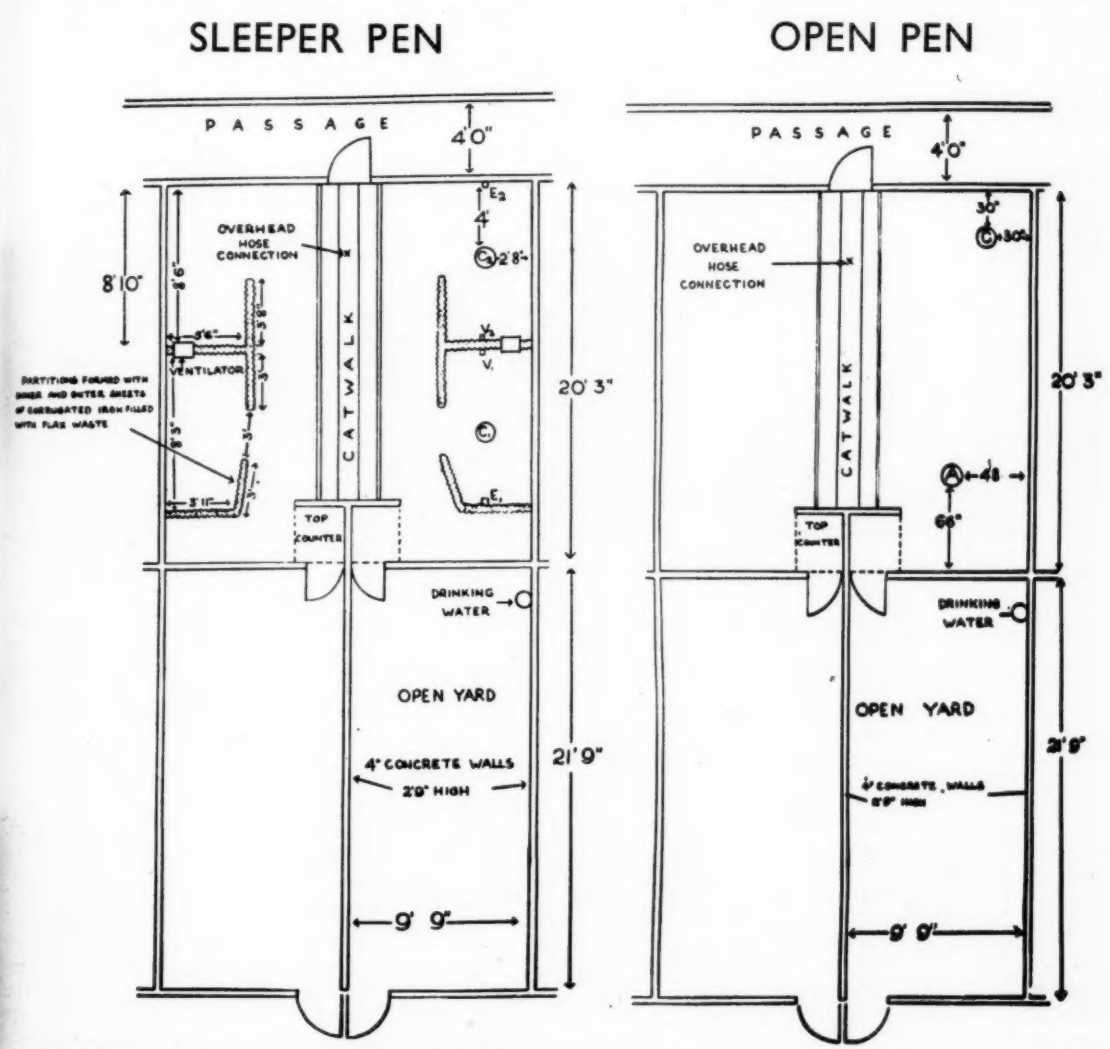


FIG. 4A.—Sleeper Pen Floor Plan. C1 and C2 indicate Thermohydrograph and Maximum and Minimum Thermometer sites. Maximum and Minimum Thermometers were also placed at E1, E2, V1 and V2.

FIG. 4B.—Open Pen Floor Plan. A and C indicates sites of the Thermohydrographs and Maximum and Minimum Thermometers.

FIG. 5.—Protector for Thermohydrograph and Maximum and Minimum Thermometer.

were housed under circular perforated metal screens 2 feet 6 inches in diameter. These were made from disused quarry screeners bolted together. (See Fig. 5.) They were kept in position by adequate weights carried on a raised platform set above the level of the instruments. Other maximum and minimum thermometers were placed at ground level as shown. These were protected by perforated metal screens bolted to the wall. (See Fig. 6.)

Air temperatures and relative humidities were recorded throughout the year using the thermo-hygrographs. Twice weekly these instruments were checked from whirling hygrometer readings. In addition daily (except Sunday) maximum and minimum temperatures were recorded for about half of the survey period. Kata thermometer readings were taken twice weekly and from these air velocities were calculated. Absolute humidity, dew point and effective temperatures were also calculated. Radiant temperature was measured for a period but these readings were discontinued since there was no marked difference found between them and air temperatures. In the later part of the period velometer readings (Metrovick) and floor and wall temperatures using a thermo-couple were measured from time to time. No serious attempt was made to measure air changes since it was the practice on the farm to regulate the ventilation on subjective impressions of the atmosphere. That such subjective impressions are of value in evaluating ventilation as far as human habitation is concerned is indicated by a report of the Heating and Ventilation Committee of the Building Research Board (1954).

All periodic readings were taken between 11 a.m. and 3 p.m. The insulation values of the various components of the house expressed as total resistance are: floor 3.22, walls concrete 1.4, wall wood 1.74, roof 3.376, sleeper walls 11, and sleeper roof 21. For purposes of comparison a $\frac{1}{4}$ inch corrugated asbestos sheet has a total resistance of 0.86. The insulation value or total resistance is the sum of the air to air resistances of the structure to the passage of heat plus the resistance of the external and internal surfaces.

Figs. 7 to 12 summarise the large amount of data collected over the year. It is emphasised that the readings incorporated in these graphs were taken at what may be regarded as the optimum time of the

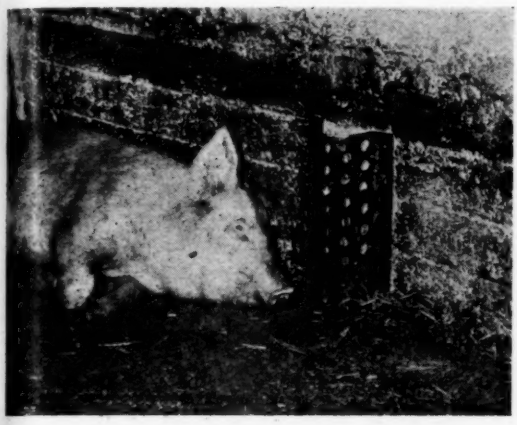


FIG. 6.—Protector for Maximum and Minimum Thermometer.

day (11 a.m. to 3 p.m.) nevertheless they do reflect certain differences between the two environments. The mean monthly figures are plotted in each case.

Air Temperature

The mean monthly air temperature in the two pens is shown in Fig. 7. As will be seen the air temperature in both pens showed comparatively little variation throughout the year. The temperature in the two sleeper areas was very constant while that recorded at Site A in the open pen was considerably lower than in the other half of the pen.

The variations in the two houses are better illustrated in Fig. 13 which shows the minimum daily temperature (as recorded on maximum and minimum thermometers) in the two houses during the month of May, 1954, compared with outside temperatures. The differences shown would presumably be even greater during very cold weather.

Minimum Temperature Differences between Inside and Outside during May

	Min. Temp. Extremes	*Mean Min. Temp.*	*Difference Inside and Outside*
Sleeper Type House	58-71°F.	65°F.	26.4°F.
Open Type House	44-68°F.	56°F.	12.4°F.
Yard	32-52°F.	43.6°F.	

Absolute Humidity (*Fig.* 8)

Both pens reflect a fair degree of parallelism between the absolute humidity of the pen and that outside. The pigs showed little or no tendency to urinate or defecate in the house and so very little moisture was being added to the atmosphere of houses apart from that arising from expired air. The absolute humidity was slightly lower in the open pen than in the sleeper pen due to greater air velocity.

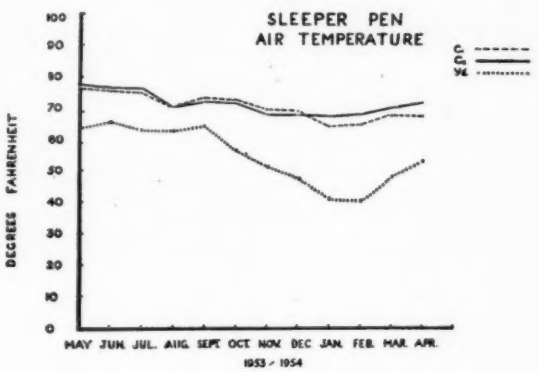
Relative Humidity (*Fig.* 9)

Both graphs record remarkably low humidities in comparison with those generally published. The relative humidity is slightly higher in the open pen than in the sleeper pen.

The Air Velocity (*See Fig.* 10)

Shows a more marked contrast between the two environments, and the equalising effect of the sleeper on the environment is well illustrated in this graph. It is probably not surprising that we were unable to find any direct relationship between the increased air velocity and the higher morbidity rate in this pen. The factors determining sickness and health are probably many and complex, yet it is felt that this variation in air velocity played some part in determining the higher morbidity rate in this open pen.

Bedford (1948) quoting Baetjer (1924) states that at a temperature of 60 to 65° F. air currents below 40 feet per minute were not perceptible on the exposed human cheek while at 50° F. a 30 feet per minute air current was just appreciated. Therefore, in the open pen at times pigs would be exposed in part of the house to an air velocity which would be considered



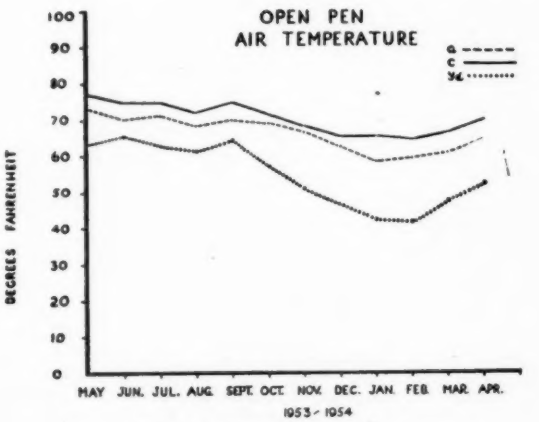


FIG. 7.—Air Temperature.

a draught from the human point of view whereas throughout the sleeper pen detectable draughts hardly ever occurred.

Effective Temperature (*Fig.* 11)

Although effective temperature scales are based on subjective impressions of warmth it has been found as far as human beings are concerned that effective temperature, which compares the combined effect of relative humidity, air temperature and air velocity in a single index, correlates very well with various physiological reactions such as pulse rate and body temperature. Here again the equalising effect of the sleeper is apparent in graphs of the two sites in this house and the effective temperature here is on the average higher than in the open pen.

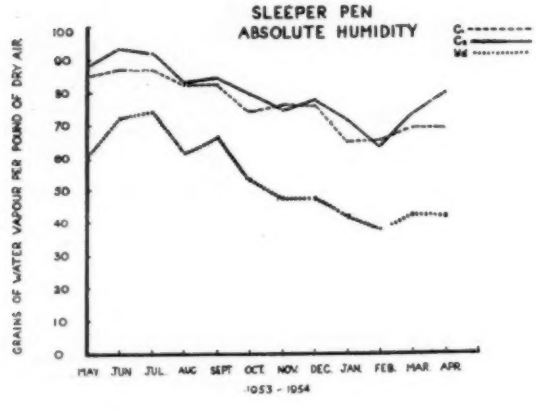

SLEEPER PEN
ABSOLUTE HUMIDITY
GRAINS OF WATER VAPOUR PER POUND OF DRY AIR
MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR
1953 - 1954
OPEN PEN
ABSOLUTE HUMIDITY
GRAINS OF WATER VAPOUR PER POUND OF DRY AIR
MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR
1953 - 1954

FIG. 8.—Absolute Humidity.

Dew Point Temperature (*Fig.* 12)

Shows a remarkable similarity between the two compartments of the sleeper in contrast with the open pen.

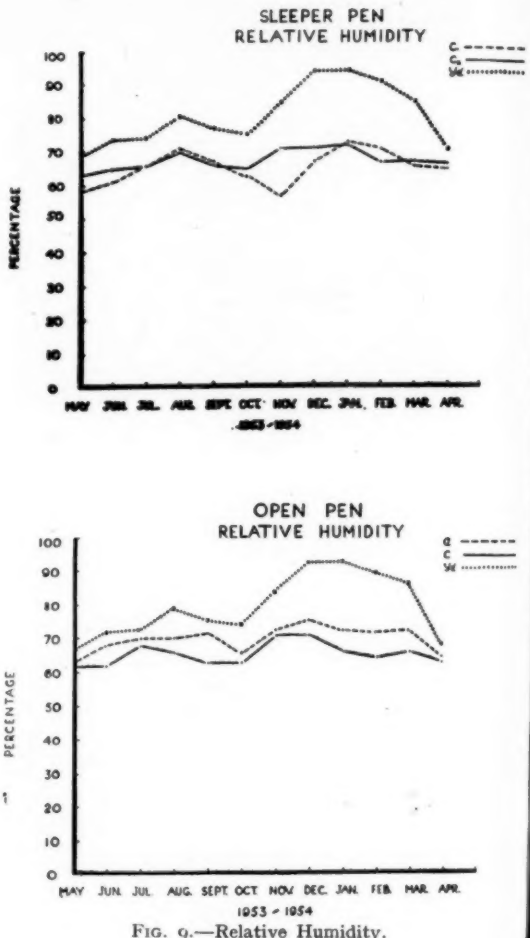


FIG. 9.—Relative Humidity.

Sickness

Details of treatment rates were kept in the two pens over the 12 months under review. (See Table I.) With the system of husbandry in operation on the farm, pigs remain in the range of houses under present examination for three to four weeks so that during the 12 months at least 700 pigs passed through each double pen.

It was of considerable interest to find that the rate of sickness in the open pen was almost twice as great as that in the sleeper pen. It should be understood, too, that the open type of pen had hitherto been considered a relatively satisfactory type of fattening house. Both pens were being fed the same ration and subjected to identical conditions of management. It is, therefore, reasonable to attribute in the main the difference in sickness rates to the structural refinements in the sleeper pen outlined above.

The difference in the sickness rates would have been even more heavily weighted in favour of the sleeper pen had it not been for the inexplicable break-

TABLE No. I

Percentage Treatment Rates 1953-54

	May	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec*	*Jan.*	*Feb.*	*March*	*April*
Sleeper Pen	1.4	8.4	14.0	4.8	6.8	97.6	10.5	31.5	4.5	5.6	1.4	3.0
Open Pen	1.9	1.9	29.5	52.4	14.6	69.7	12.4	13.5	48.1	15.1	1.4	35.3

Average monthly treatment rate percentage

Open Pen	26.9
Sleeper Pen	15.9

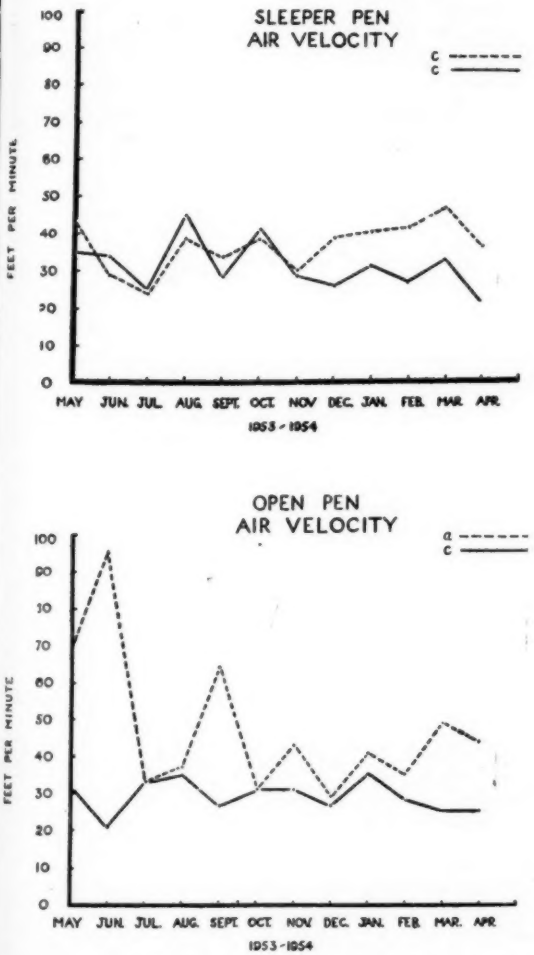


FIG. 10.—Air Velocity.

downs in health during October and to a lesser extent in December, 1953, in the sleeper pen. Certainly we were not able to correlate these sudden jumps in sickness rate to any of the factors being measured. It will be noticed that the open pen suffered a similar but less severe breakdown in October. It is, however, incidents such as this that serve as a salutary reminder that the environment cannot be divorced entirely from the organism it contains and that the final comprehension of many problems presented by the intensively kept pig still remains in the future.

Table I shows the number of treatments carried out expressed as a percentage and not the number of individual pigs which were treated.

Food Conversion Rates

Over a period of 209 days during which six different batches of pigs passed through each pen, the food conversion rates were computed and details are given in Table II.

TABLE No. II

Period	*Open Pen*	*Sleeper Pen*
28 days	3.37	3.20
37 ,,	3.43	3.32
56 ,,	3.85	3.79
32 ,,	4.45	4.16
35 ,,	4.44	4.36
21 ,,	3.32	3.35

Average conversion rate percentage

Open Pen	3.81
Sleeper Pen	3.70

Figures have been computed on a weekly food consumption basis against the number of pigs in the pen at the commencement of the current week.

Discussion

The evolution of the present day pig housing system at Cloughmills has been a gradual process. In the period up to 1942 the main problem tackled was the conservation of the pigs' natural heat and the house described by Shanks (1942) had been evolved largely with this end in view. However, without the aid of elaborate and costly systems of air conditioning there are considerable difficulties in maintaining optimum housing conditions all the year round in view of the vagaries of our climate; temperatures may alter alarmingly, especially in spring and autumn, winds can increase swiftly and veer rapidly, and any one or more of these can impose a critical stress on the regulatory mechanism of the pig house.

What may be called "hot weather pneumonia" can become a problem in an insulated environment dependent on natural ventilation in our climate. The changes in the house between 1942 and 1952 were designed to overcome this problem, being in the

main attempts to provide better and more controllable ventilation during periods of hot weather.

The pigs prior to entering the pens under discussion were housed in an insulated sleeper type of building. Here they invariably throve extremely well and morbidity figures were practically non-existent. It was in view of the very successful results at this earlier stage that the insulated hut idea was extended to the older group of pigs.

It is a routine practice on the farm to inspect all pigs at least once daily. Sick pigs are treated in the pen but any seriously ill are removed for treatment in hospital pens. The treatment figures given represent mainly cases of respiratory conditions. The present figures for treatment rates in the two houses are regarded as a very important indication of environmental suitability or otherwise. Epidemic disease was absent in the pigs during the period of the survey and while pneumonia virus was present, the effects of this condition are notoriously sensitive

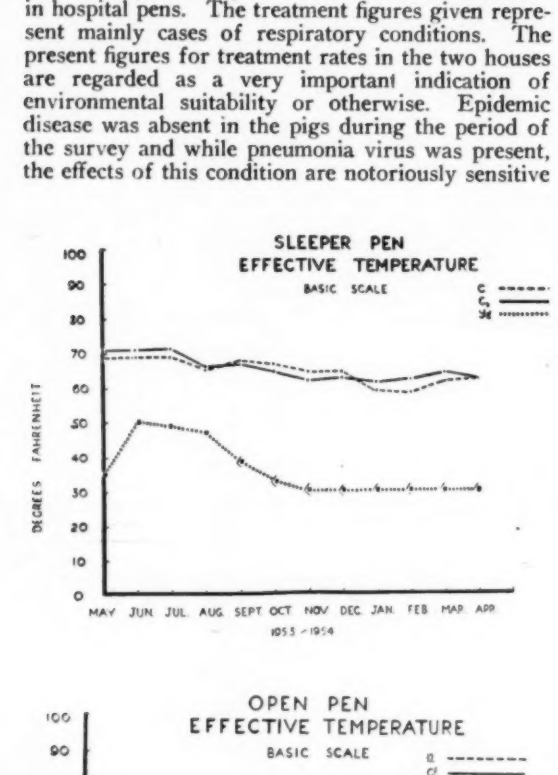


FIG. 11.—Effective Temperature: < Indicates that one or more of the readings were less than the minimum which could be calculated from the tables.

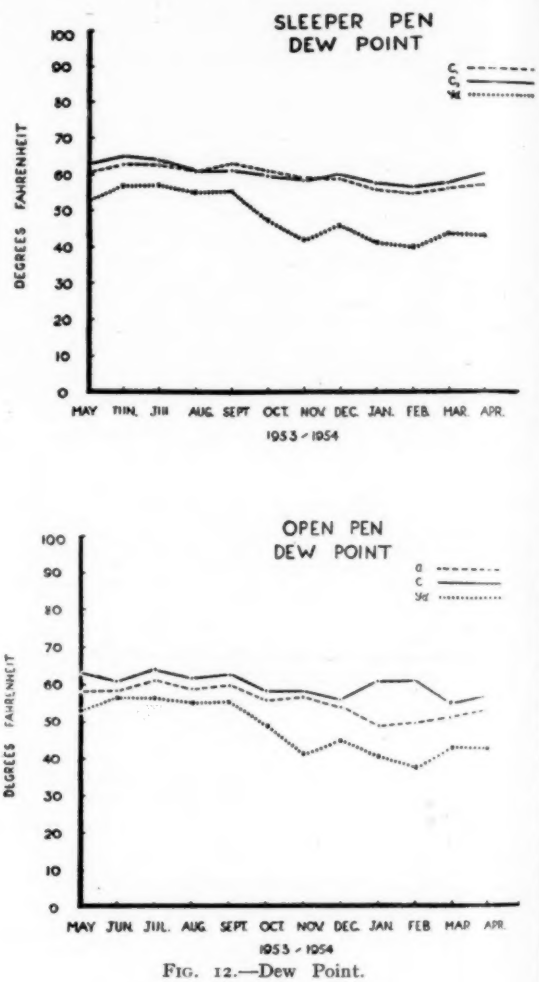

SLEEPER PEN
DEW POINT
DEGREES FAHRENHEIT
MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR
1953 - 1954
OPEN PEN
DEW POINT
DEGREES FAHRENHEIT
MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR
1953 - 1954

FIG. 12.—Dew Point.

to environmental fluctuations. In the existing conditions there is no doubt but that the treatment rates definitely favour the sleeper type of house.

Although there is not a marked difference in the food conversion rates between the two pens, there is nevertheless a difference in favour of the sleeper pen. That this is not more marked, considering the difference in the treatment rates, is perhaps due to the fact that in a great many cases of sickness pigs responded to one or two treatments. Presumably, therefore, such pigs were not sick sufficiently long to markedly influence their food conversion rates.

The present house, then, provides several environments within the one building. In very cold weather the pigs crowd into the sleeper and the restricted air space here helps to maintain adequate temperatures. As conditions improve the pigs will spread out over the whole inside floor area and in very warm weather some will sleep in the closed-in verandah. The sleeper is intentionally divided into two compartments. This not only lessens bullying but where the

house is not filled to capacity one sleeper may be closed off thus ensuring adequate temperature in the compartment being used. With the house as it was in 1942 pigs sleeping in the outside run presented a problem during spells of very hot weather. With the sudden drop in temperature which is so likely to occur in the early morning such pigs were often chilled and illness followed. With the present type of house the pigs can be confined to the house or verandah on warm nights with, of course, suitable adjustments to the ventilation and the chilling effects of "camping out" thus avoided.

The open type of verandah has one important disadvantage which was discovered during the present work. With the wind on the front of the building the open verandah tends to act as a funnel and thus create floor draughts at the pen entrance, and this in spite of having the door baffled with an inner porch. Such floor draughts are undoubtedly harmful to the welfare of the pig and could contribute to the over-all morbidity rate.

The siting of the instruments is of great importance in evaluating the pigs' immediate environment and surprisingly wide differences have been recorded by thermometers situated at ground level and at a height 3 feet 6 inches approximately. For example, in the building used by the pigs at the stage before being transferred to the house under examination in this paper, floor temperatures taken at the entrance to the sleeper were commonly 8 to 14° F. below those

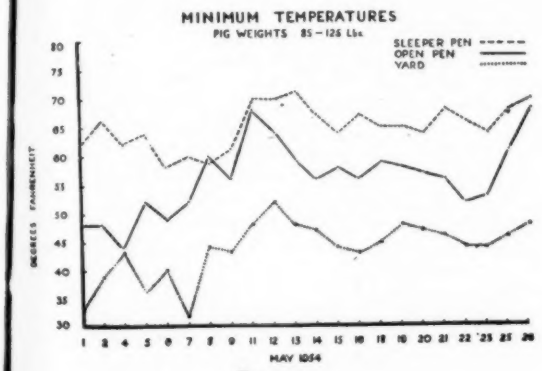


FIG. 13.

at the same site 3 feet 6 inches above the floor, and on one occasion a difference of 26°F. was recorded. Over the month of January, 1955 the floor temperature at this site was on the average over 12° lower than that recorded 3 feet 6 inches higher up.

Similar observations have been made in the house occupied by the other age groups but space does not permit their evaluation here. It is proposed to conclude this paper with a consideration of the mortality figures on the farm. Mean monthly mortality rates from birth to killing have been worked out for the years 1937-39 and 1951-53. These are depicted graphically in Fig. 14.

The numbers of pigs involved in these two periods were: 30,576 in 1937-39 comprising 21,114 born alive on the premises and 9,462 purchased as weaners. In the period 1951-53 the number involved was 24,747 pigs comprising 21,286 born alive on the premises and 3,461 bought in as weaners. The average mortality birth to slaughter in 1937-39 was 26.16 per cent. and in the period 1951-53 it was 16.67 per cent. The pattern of mortality in 1937-39 is fairly typical of that reported elsewhere in that there is a general decline in spring and summer with increases in autumn and winter. Twice as many pigs died in January or February as in July, and this

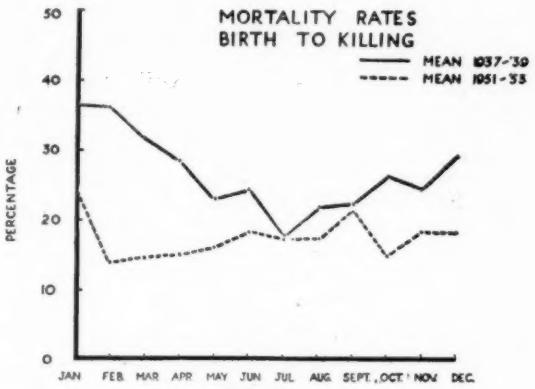


FIG. 14.

curve pattern indicates environmental insufficiency in the colder months of the year. The 1951-53 curve is much more horizontal and indicates how winter losses have been reduced.

The mortality rates for the same two periods for pigs eight weeks and over are shown in Fig. 15. Here again there has been a remarkable reduction in losses in favour of the 1951-53 period. In addition any seasonal influence has almost been obliterated. Within this age group the mean percentages were for 1937-39 9.02 per cent. and for 1951-53 1.37 per cent.

The percentage mortality rates for pigs two to eight weeks are illustrated in Fig. 16. Here again there has been a well-marked drop in mortality in the 1951-53 period for this age group with the same

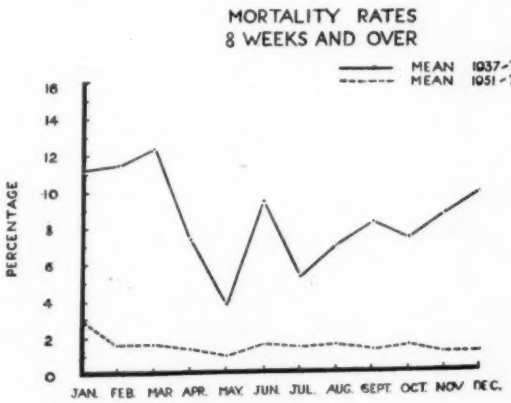


FIG. 15.

tendency for seasonal influences to disappear. In the period 1937-39 10.26 per cent. died between one and eight weeks while in 1951-53 the figure was 6.72 per cent. During the period 1937-39 almost two and a half times as many pigs within this age group (one to eight weeks) died in January as in July.

The mortality rates for pigs one to six days are shown in Fig. 17. The average percentage for 1937-39 was 6.9 and for 1951-53 it was 8.58. It would, therefore, appear that least progress has been made in the control of losses within this group. It will be seen that the mortality fluctuated throughout the year and within the period 1937-39 pigs born in June had the same risk of dying in the first week as those born in October. A reasonable inference from these figures is that within the first week in the two periods under study the environment provided at Cloughmills was not a critical factor in survival. In the intricate adjustments necessary between intra-uterine and independent existence there are many factors determining the outcome but these are outside the scope of the present survey. One possible influencing factor in the results within the 1951-53 period may be cited. A rapid expansion in the breeding programme took place during this period. In 1951 5,699 pigs were born on the farm whereas in 1953 8,682 live births were recorded. This meant that a higher proportion of gilts than usual were farrowing each year during this period.

The main progress then in the other age groups has been in the reduction of winter losses, but we do not intend to infer that this has been brought about entirely by improvements in housing. The use of modern therapeutics has undoubtedly played a major part in this improvement. While mortality is one of the more easily determined yard sticks of the success of any pig enterprise there must be few practical pig farmers who will not agree that morbidity may

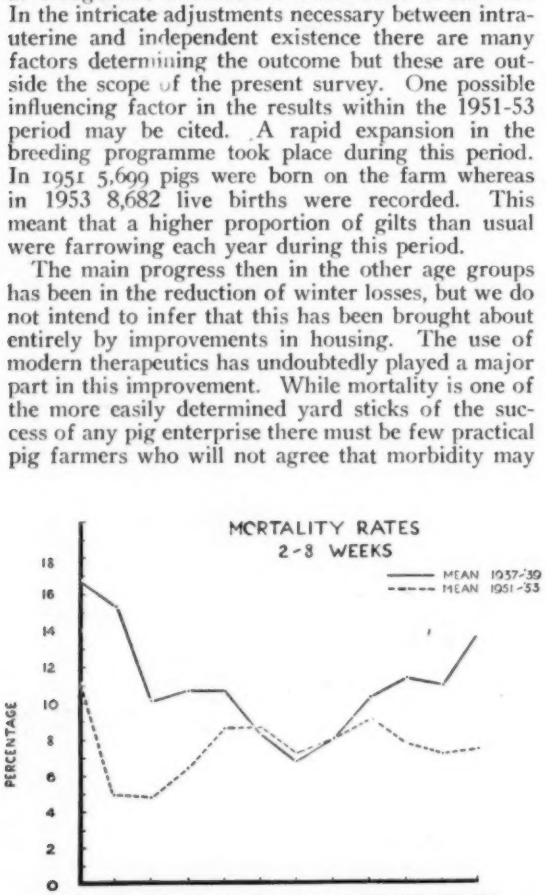


FIG. 16.

often determine profit and loss. Too many pigs taking two, four, six or more weeks to reach bacon weight could convert a reasonably sound pig venture into a financial failure. It was realised during the preliminary investigations that the alterations (provision of sleeper area, etc.) were likely to affect not only

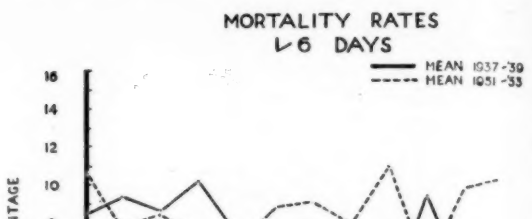


FIG. 17.

mortality but also to have a favourable effect on morbidity. The success achieved in this direction is indicated in Table I in which treatment rates in the 1937-39 environments are compared with those in the modified sleeper type of house.

Summary

The paper presents data relating to the physical environment of pigs between 80 and 125 lb. collected over a period of 12 months on an established commercial pig farm. Air temperature, relative humidity, absolute humidity, air velocity, effective temperature and dew point were measured in two environments: the so-called open type of house as used up to 1952 and the sleeper type of house modified in accordance with most recent ideas. Information also obtained regarding pigs receiving treatment during the survey period and for part of this period food conversion rates were computed.

In addition over-all mortality rates were calculated for the three years 1937-39 and compared with those for the period 1951-53. A downward trend in favour of the latter period is shown for all age groups except for pigs one to six days old. The significance of these figures in relation to the environment and the part played by modern therapeutics is discussed.

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THE SPEAKER'S INTRODUCTION

The Chairman (Mr. P. L. Shanks) said that the paper about to be considered was based on work carried out on the farm of McGuckians at Cloughmills. The North of Ireland workers were particularly fortunate in having that farm more or less at their disposal for experimental purposes, and he could vouch personally for all that was said at the beginning of the paper about the collaboration and whole-hearted support that the veterinary profession got from the McGuckian brothers. Formerly there were three of them, but the eldest one died a few years previously. The enthusiasm and co-operation with the profession had never-

theless been continued by the two other brothers, Gerald and Brian, who were present at the meeting. It was a great tribute to the veterinary laboratory at Stormont and to the McGuckian brothers that they had been able to produce such a very valuable paper, the most recent of a number of other papers on the work that had been carried out at Cloughmills.

The paper now to be considered was on work carried out during the past year, and Mr. Gordon would make a short introduction.

Mr. W. A. M. Gordon: "Dr. Luke and I would like to express our sincere appreciation of this opportunity to focus attention once again on this all-important subject of environment. I personally feel that our profession, if it is to be criticised at all, tends to overlook basic principles in its approach to pig problems.

"We are indeed most fortunate in having both Mr. Brian and Mr. Gerald McGuckian with us this morning, and we are very grateful for their co-operation in inviting us to Cloughmills this afternoon. The changes which have been made at Cloughmills and outlined in the paper have beyond all question of doubt proved of immense value during the very hot weather we have had this summer. Records which are maintained by the McGuckians at Cloughmills show that the treatment rate has been lower than ever before. I should like to give you a few figures recorded in one of the fattening houses during July of this year.

"Out of sixteen readings taken during the months of July by maximum and minimum thermometers, eleven showed a temperature of 90°F. or above, the maximum temperature being 95°F. Despite these temperatures the pigs throve extremely well and treatment rates were phenomenally low. The only change in the pigs' behaviour was that they reacted to their natural instincts and wallowed. Those of you who visit Cloughmills this afternoon will see this.

"I am sure Mr. Shanks will be most interested to hear these figures as he was so intimately associated with the McGuckians' farm and all the developments made at Cloughmills some years ago. In his article 'The Housing of Pigs' Mr. Shanks recommended that the temperature of the house should not fall below the critical temperature of the pig and should be higher, preferably and in the region of 80°F.

"You will perhaps have noticed that in the recorded temperatures for the year 1953-54 much lower temperatures are shown. This is due almost certainly to two factors: (1) the siting of thermometers at ground level, and (2) the fact that the outlet ventilators had been increased—in fact, doubled. This increase in ventilation outlet may be over generous, 6 sq. ins. per pig, approximately, but provided the outlet is controllable, as at Cloughmills now, no harm need ever result.

"In conclusion, may we make a plea for a more comprehensive outlook on environment. Too often we are asked questions such as, 'What temperature should be maintained in a piggery?' 'What is the most important factor in pig housing?' Questions such as these are on the level of 'What is the most important ingredient in a plum pudding?' and cannot be provided with a simple answer."

The Opener

The Chairman said it was quite often a difficult task for the Provisional Committee to decide upon a suitable opener of a discussion, but in this case there was no doubt at all as to who should be the opener. The choice was, of course, Dr. Sainsbury. He had been working on the problem of pig housing for a number of years and probably on a different line from that of the Stormont workers because they had worked on the trial and error method, while Dr. Sainsbury worked on fundamentals. They looked forward with great interest to what Dr. Sainsbury was going to say.

Dr. D. W. B. Sainsbury (Potters Bar) said: "Firstly I greatly appreciate the honour of being asked to open the discussion on this paper. Before making any comments on this very valuable contribution by Dr. Luke and Mr. Gordon I feel that this is an appropriate moment to pay tribute to the workers who have done so much to improve our knowledge in the field of pig housing. I doubt whether any event has been of more importance in this connection than the association of Messrs. McGuckian with Professor Lamont and our chairman today, Mr. P. L. Shanks. Study of their publications in the 1930's and early 1940's makes it obvious that they succeeded years before others in realising what was wrong with the older type of house, and what measures could be taken to overcome these troubles successfully. What they did, then, is increasingly being carried out today with real benefit, though the value and importance of their pioneer work, together with that of our authors, Dr. Luke and Mr. Gordon, is still not sufficiently appreciated, nor is it being acted upon as much as one could hope. Then, in addition to the work carried out in Northern Ireland, most valuable contributions have been forthcoming from Scotland, and I would wish particularly to draw attention to, and acknowledge the work of, Mr. Inglis and our President, Professor Robertson, carried out at the Royal (Dick) Veterinary School, that of Mr. D. S. Soutar, Head of the Farm Buildings Department, North of Scotland College of Agriculture and author of a paper at the B.V.A. Congress at Aberdeen two years ago and promoter of so many good ideas, together with important housing studies carried out at the Rowett Institute and recently in the hands of Dr. I. A. M. Lucas and co-workers.

"Some papers tend to be so full of incontrovertible matter that it is quite impossible to discuss them to any extent. In contrast the contribution by Mr. Gordon and Dr. Luke leads naturally to discussion. I think the authors would agree that first and foremost their paper is a practical man's paper, and the information they have obtained is of immediate use to the farmer and the veterinary surgeon. This paper shows very thoroughly and clearly that under the particular type of management and housing conditions of the McGuckians, what might be termed relatively small differences in the housing and the environment can make significant differences in health and productivity. As the comparison between their so-called 'sleeper' pen and 'open' pen shows, there were differences in all the indoor climatic elements between the two types—temperature, humidity, and air velocity, and therefore ventilation rates as well. It is of course difficult, as in all 'field' work of this nature, to be sure which one of the climatic factors, if indeed there was any one, had the predominant influence. Certainly, on the face of it, perhaps most significant of all were the very considerable differences in air velocities between the 'sleeper' and 'open' pens. This, together with the marked differences in air velocities recorded between the two parts of the 'open' pen make it appear as though the baffles between pen and yard are insufficient, and/or the ventilators are not sufficiently controllable.

"I should therefore be glad if the authors could give details of the baffling employed, as from evidence I shall present in a moment, I think one can attach considerable importance to this. Houses of this type with good sacking or rubber strip baffles, seem to be able to eliminate such air velocity gradients as described by the authors.

"I presume the essayists would not advocate the use of a 'sleeper' house within a house except as a modification of an existing building, since the favourable conditions obtained by using this type of arrangement, as far as I can see, can be obtained in a new house by reducing cubic air space, improving insulation and tightening up on the prevention of draughts.

"The mention made by the authors of cross-ventilation is particularly interesting because it appears to be increasingly clear that provision of this in pig houses—or animal buildings generally—is absolutely essential for summer ventilation and also for humid conditions in general, perhaps more particularly in sheltered positions in Southern England. But whereas it can be an essential requirement in summer, it can be extremely dangerous at other times, and a system using outlet chimney vents and utilising the so-called 'stack-effect' as used in the McGuckian houses is always to be preferred for general cold weather use.

"I gather that the outlet ventilation in McGuckian's houses is partly fixed open. Does not this tend to cause draughts? I am very firmly of the opinion that all ventilators in pig (and poultry) houses should be controllable because of the very great variation in air change rates required.

"The observations regarding 'treatment rates' are very

revealing, but I do not follow whether these figures are very strictly related to 'sickness rates.'

"I believe that the principle of having warm insulated pens with partly covered yards attached has more to commend it than any other system of keeping the fattener. Of this type of house, the McGuckian's have produced what, in my experience, is far and away the best. It is not that equally good results cannot be obtained in other types, *viz.*, a good Scandinavian house, or a good deep dunging house, but it is so much easier to keep the environment dry, warm and draughtless in a McGuckian house. This is clearly due to several factors—the pigs dung outside, and can be watered outside, so pollution of the air and excessive dampness are avoided. The smaller units make control of draughts very much more simple. As cubic capacity is more or less at a minimum, insulation is the more easily and cheaply achieved, and ventilation because of this is the more easily effected—though regarding the latter point some poor imitations of McGuckian houses have been erected in England, and in which the importance of good ventilation has not been realised. They have for this reason often proved unsatisfactory.

"It may be interesting to record that we found the ventilation rates in McGuckian houses can be under half those necessary in totally enclosed buildings, whilst still keeping humidities and general freshness at the same level. (Actual figures are 300 cu. ft./pig/hour in a McGuckian house, 700 in a good Scandinavian house and 800 in a good deep straw house). This reduced ventilation rate in the McGuckian house of course assists in raising temperatures and reducing risk of draughts.

FIG. I

SATISFACTORY AVERAGE VENTILATION RATES DURING THE MONTHS SEPTEMBER TO APRIL

Type of piggery	Ventilation rates required per 200 lb. Pig (cu. ft. per hr.)
Well insulated pen with outside yard for dunging	300
Well insulated totally enclosed piggery with dunging passage	700
"Deep straw" piggery of sound construction	800

"It is most important not to think in terms of temperature alone when considering 'environments' and our essayists have shown this point up well in their complete studies which covered all the climatic elements. It is, however, a pity this comprehensive view of matters has not always been taken. The American workers, Heitman and Hughes (1949) found that the optimum temperature for fattening small numbers of pigs in the highly artificial environment of the psychrometric room lies between 60°F. and 73°F. Now this is an important finding, but it is quite divorced from all the practical difficulties associated with actually obtaining such temperatures, without unduly polluting the atmosphere and restricting ventilation. If a house is well insulated and ventilated and the pigs' dung outside such temperatures are indeed feasible—for proof one has only to look at the paper we are discussing. But for other types of housing it may be dangerous to try and obtain it. Perhaps one should not think in terms of one range of optimum temperatures at all, since it is clear that each house, each feeding system, and each type of management may have its own optimum temperature associated with it.

A few years ago we were conducting some studies on the environment in a piggery where the temperature was running 10-20°F. below the optimal levels for fattening pigs given by Heitman and Hughes. In this case low temperatures were due to the unduly high cubic air space provided, associated with a very high air change rate. To try and lift up these temperatures, ventilation was severely restricted and we certainly achieved nearly the required temperatures. But the effect of these measures on productivity was alarming in the extreme, as conversion ratios went from the region of 3 to 10, and weights more or less stood still. It is noteworthy that our figures of 400 cu. ft./hour/pig which proved so unsatisfactory in this type of house, and led to such a high humidity, appears quite sufficient, in a good McGuckian type for instance, where the pigs dung, etc., outside. Certainly temperature isn't everything!

FIG. II

EFFECT OF RESTRICTING VENTILATION TO RAISE TEMPERATURE IN A TOTALLY ENCLOSED PERMANENT PIGGERY WITHOUT DUNGING PASSAGE

	Conversion ratio	Temperature	Average relative humidity	Ventilation rate: per Pig per hour
		°F.	per cent	cu. ft.
Before and after restrictions on the ventilation	2·5–3	40	70	2,400
During the restrictions	9·2–10·2	60	90	400

(Number of Pigs in Trial—72)

"A further example shows how critical ventilation requirements can be in the fattening house. In operation here were three piggeries of the insulated pen and outside yard type, and it was observed from the owner's records that whilst the pigs throve during the winter (conversion ratio 3.5), they did relatively worse in summer (conversion ratio 5.5). Food was identical on each occasion, and pigs compared were from the same boars and sows. Temperatures and humidities in the summer were, however, high but ventilation rates were very low, compared with averages in other well-run piggeries. Improvement in conditions was achieved by installing stale air inlets (previously absent) and greatly increasing outlet area. The result was an overall 3.6 conversion ratio the following year.

FIG. III

EFFECT OF INSUFFICIENT VENTILATION IN THREE PIGGERIES CONSISTING OF INSULATED PENS WITH YARDS ATTACHED

	Ventilation deficient		Ventilation sufficient	
	Jan.–June	July–Dec.	Jan.–June	July–Dec.
Conversion ratio	3·5	5·5	3·6	3·6

Ventilation corrected without recourse to mechanical aids
(Number of Pigs in trial—60)

"Linking up ventilation rates with air velocities, which appeared to be one of the foremost differences between sleeper and open pens found by Mr. Gordon and Dr. Luke, we were interested in the findings in a heated piggery where temperatures were kept fairly constantly at about 60°F. Yet one March it was observed that fatteners were gaining gradually less and less week by week until at seven score liveweight they were gaining a mere 6 lb. each a week. It was certain that the place was draughty, and by closing the windows to a fraction of their former value, the week following the pigs averaged 15 lb. increase each on the same quantity of food and the same temperature.

"It was purely coincidence that in the winter of 1953-4 experiments were conducted in collaboration with A. C. Dunkin of Wye College, in McGuckian type houses, on similar lines to those described by Dr. Luke and Mr. Gordon—though numbers involved were very small in comparison. (64 pigs.)

"In these houses it was found that results were very satisfactory but there was no yardstick for genuine comparison. Therefore, in order to get some information on this point, one double pen was 'de-baffled,' that is, baffling was removed

FIG. IV

THE EFFECT OF TWO DIFFERENT ENVIRONMENTS ON FATTENING PIGS

	°F of inside temp. above outside average	Daily gain in weight lbs.	Food conversion ratio	Per cent lungs clear of any pneumonic lesions P.M.	Per cent showing active pneumonia
Pen "A" Well "baffled" and insulated McGuckian type	22	1·37	3·69	34	4
Pen "B" As pen "A" but with all "baffling" removed	14	1·29	3·85	17	17

(Number of Pigs in trial—64)

between pen and yard and the doorway between pen and passage was left open throughout the winter (which was actually a fairly warm one). Otherwise the house remained well insulated and could be considered a reasonable pen, at any rate not unlike many piggeries. If, however, one looks at the results one can see that differences, so far as food conversion ratios were concerned, were almost identical with those of our authors. It is also seen that the daily live weight gain was better in the well baffled pen, and pneumonic lesions (virus pneumonia was present) certainly favoured the better pen.

"This may be an appropriate moment to raise the important question of virus pneumonia of pigs. The very valuable contributions of Professor Beveridge, Dr. Betts and their colleagues are acknowledged in this field and, arising from their work, it now appears that many pig farmers attach great importance to the presence of this condition. The evidence of these workers has clearly indicated that pigs experimentally infected with Virus Pneumonia show a considerable depression in growth-rate and efficiency of food conversion. (Betts *et al.* 1955.) These authors suggest that in the field virus pneumonia depresses the growth rate and food conversion by at least as much as in their experiments: but I wonder if this is always the case. I would agree that this occurs under bad housing and management conditions and when infection is freshly introduced, but when management and housing are good, and the infection has been present for some time, we have found no such clear-cut evidence, and in fact some of the best results we have collected have been in infected and non-infected herds alike. I would not wish to draw any conclusion one way or another but would appreciate the observations of our essayists on this question, particularly since their data indicates the difference between 'sleeper' and 'open' pens with regard to respiratory disease.

"I would not wish it to be thought from some of my remarks that I do not attach importance to temperatures in piggeries. Work conducted in a co-operative venture at the British Oil and Cake Mills Progeny Testing Station at Stoke Mandeville showed us how a little insulation of wooden huts accompanied by only a small increase of temperature could significantly increase efficiency of conversion and liveweight gain. (Conversion ratios were: controls, 4.15; insulated huts 3.78; reflective insulation 3.74). The differences shown on this slide can make a difference of 15/- in the profit on a bacon pig—that is about £6 a year on each hut. The cost of insulation can be as little as 25 per cent. of the gain in profit over a year—for example with reflective insulation.

"I think very great importance should be attached to figures given by Mr. Gordon and Dr. Luke for seasonal and yearly trends in mortalities. It is clear that whereas

FIG. V

THE RELATIONSHIP BETWEEN EFFICIENCY OF FOOD CONVERSION AND THE INSULATION OF WOODEN HUTS

	Controls	Insulated huts	Huts with reflective insulation
Conversion ratio ... (10 weeks to bacon weight)	4·15	3·78	3·74

(Total Numbers—18 Groups of 4 Pigs).

previously (1937-9) some very marked seasonal trends were operating and at all ages mortalities were most serious from October to April, in the period 1951-3 there was little evidence of a seasonal incidence at all. This obviously reflects great credit on the McGuckians and their veterinary advisers. For comparison, in a survey we carried out in Southern England we found a marked seasonal trend with bad housing conditions but none with good housing. No doubt good management paralleled good housing, and bad management, bad housing, so one would not claim it is entirely the effect of housing. We also found in our survey of 50 pig houses that in winter pigs would take 1-2 months longer to fatten in 'bad' houses compared with good. I have always been anxious to know why there are generally fewer mortalities in February than in January or March, a point also seen in Mr. Gracey's paper given yesterday. I wonder whether it is due to the dryness of the air during this period, and/or, the fact that the winds are generally lower?

"I think, therefore, one can conclude from the various field observations that have been made that whilst the pig is by no means a delicate animal, his enforced maintenance in large numbers in closely confined quarters does make the problem of providing correct conditions quite a delicate one, and furthermore it is evident that all of the individual climatic elements—temperature, humidity, draughts, air change rates, play an important part, though the exact part each one plays, and their relative importance, waits to be determined, and is a vital aspect of future pig research. Unfortunately, research on animal housing in general seems to inspire few workers.

"General conclusions that may be of help to the pig farmer might be listed as follows:—

"Firstly: Elaboration of design is wasteful and unnecessary. The maintenance of reasonably small numbers of pigs in climatic isolation makes the problem of providing a correct environment much easier, and is made still easier if the pigs can dung, urinate and be watered outside. Also they can be packed in more tightly, and costs are reduced

"Secondly: Mechanical ventilation (or heating) for the fattening pig need not be resorted to, though of course it makes control of ventilation easier.

"Thirdly: Extreme elasticity of ventilation to cope with different weather conditions is an essential, and stability of conditions from day to day and season to season are essential.

"Fourthly: Every different type of piggery appears to have its own optimum environment and requires quite separate consideration to give equivalent rates of productivity—for example, conditions found excellent in a McGuckian house may not be desirable or feasible in a Danish house.

"Fifthly: It may be positively harmful to use the thermometer as a guide to what conditions should be, in view of the importance of other factors. Perhaps the best guide is, indeed, the 'subjective impression' if temperature *and* humidity records are not taken.

"And lastly: Improvements generally pay for themselves quickly in improved productivity.

"Aristotle (Book VI 18, 573, translated by D'Arcy Wentworth Thompson) records that domesticated and wild swine bring forth litters of up to 20, can be fattened for market in 60 days and that the flesh of the pig weighs five-sixths of its live weight. One may ask what progress we have actually made since then!"

FIG. 6.

References

Betts, A. O., Whittlestone, P., Beveridge, N. I. B., Taylor, J. H., and Campbell, R. C. (1955) *Vet. Rec.* **67** 661.
Heitman, H., and Hughes, E. H. (1949). *J.Amer.Sci.* **8** 171.

The General Discussion

Mr. W. Tweed (Chester) said that he had read and re-read the title of the paper and the paper itself and came to the conclusion that Mr. Gordon and Dr. Luke could go hunting in any line of country under such a title. The paper dealt principally with the effect of housing on the productivity of pigs, and tribute should be paid to the North of Ireland Advisory Veterinary Service and to the McGuckian brothers for focussing attention on the importance of housing in pig management.

Farmers had been sent to the McGuckians to copy their houses. Although builders could now be trusted to put up a shed that would enable a cow to be suitably housed, the most dreadful piggeries could be built. The time had arrived when veterinarians must take an interest in pig housing so that when requested to give advice on the construction or alteration of a piggery they could do so. The paper, unfortunately, did not help very much in that direction; and there could be some standardisation of a piggery which would meet the needs of the rank and file of pig keepers.

No one was overkeen to build monuments, but with an increase in pig keeping and reconstruction of farm buildings, pig houses did not yet appear to have reached a satisfactory standard. What was most important was to maintain a reasonably dry atmosphere. To do this required hollow walls, insulated roofs and floors, no through draught and the right cubic capacity for the number of pigs which could be fed on the floor space. Allowing trough space of one foot per pig and working on these principles it was possible to erect a 10 ft. by 7 ft. house, 6 ft. high at the eaves with a slight pitch to roof and a baffled entrance of 18 in. wide carried to the eaves, which acted as adequate ventilation, with an enclosed open yard adjoining; this house would accommodate ten pigs and maintain a steady temperature in most weather.

If several of these units and a feeding passage were desired, the inside wall of the passage could be so constructed that part of it overlapped the feeding trough inside, and the opening to the trough for feeding could be closed with a lid. This maintained the "three intact wall" principle with no through draught. A small window could also usefully be incorporated in this inside wall if desired. It would seem to be better to concentrate on a pig-sty of units of this size rather than to house large numbers of pigs together. In this way isolation of pigs was possible, and avoided the fluctuations of temperature which occurred when pigs were withdrawn for slaughter and a reduction in numbers resulted.

The Danish type of house favoured by the large pig producer had the merit of being labour saving, but this type of house provided no isolation against virus pneumonia. To be efficient it required extractor fans fitted along the outside walls over the dunging passages, and the maintenance of a constant temperature by heaters and a thermostat.

The housing of sows and litters also had its problems. Field arks were the favourite method for farms with dry land or for summer farrowing, but during winter they could be very unsatisfactory on wet land. With the small unit type of house described above it was possible to use these as farrowing houses when necessary.

Did the authors think that an accredited or certified virus pneumonia-free herd scheme would be a practical proposition? He personally felt that the control of this disease was closely linked with suitable housing.

Professor Baskett (Queen's University, Belfast), said that as an agriculturalist butting in where angels feared to tread, he would like to question whether they were not all wrong in accepting that there should be an outward ventilation at the top of a house instead of inward ventilation. A good deal of work had been done in America on this subject, particularly in regard to poultry houses. A slight positive pressure was maintained in the house by bringing air in at the top of the house or at the peak of the roof, by means of fans, and releasing it through vents at floor level. From the physiological point of view there was something to commend this principle. One should remember that it is the climate 1 in. — 18 in. above floor level which must be considered from the animals' point of view, and it would probably be useful to investigate the CO_2 density in the atmosphere at these levels in pens in which pigs were housed. There was also the question of the relative humidity of the atmosphere. Those who had lived for some time in a hot climate realised that it was possible to be reasonably comfortable at temperatures of over 100°F., provided relative humidity was low. On the other hand, if humidity was high then a temperature of 85°F. could be extremely uncomfortable. Thus if the normal method of ventilation in a pig house were to be reversed by bringing in cool air at the top of the house this air would be warmed by the time it reached floor level, and on its way to the vents at floor level would tend to dissipate the moisture in the atmosphere immediately above the dung passage. This would have the general effect of checking a rise in the relative humidity of the air in the whole house.

Mr. A. L. Walther (Liverpool) said that the McGuckians had helped him very much as far as the design of a piggery was concerned, Mr. Souter had helped him very much so far as ventilation was concerned, and that made a tremendous difference to the McGuckian type of piggery. They all should be most grateful to the group of workers at Belfast. As had been suggested, temperature was comparatively unimportant when compared with humidity; so much so that he had begun recording food conversion rates against relative humidities, and the results were encouraging. A factor which had not been mentioned was that of moving pigs from one pen to another. The McGuckians left pigs only for a short while in one pen. Those who took the trouble to weigh their pigs would find the effect of movement on food conversion efficiency was quite remarkable. It might be better to leave pigs longer in one place. The McGuckians were dealing with extraordinarily large numbers and had to grade the pigs according to size and so on, but a piggery similar to the McGuckian type, with smaller pens, would probably be better for the average man so that he could leave his pigs for longer in one place.

The question of controlling the number of pigs per pen was of the greatest importance with regard both to temperature control and humidity control.

A speaker said he would like to pay tribute to the enormous amount of work that had gone into the preparation of the paper. With reference to the final product, what relative difference had there been in the carcase grading of the pigs in the two environments? That seemed to be a point of considerable importance that had not been covered.

The Replies

Dr. Luke, in replying to the discussion, said it was always hard to decide who should answer questions on a paper written by two authors, but he would have one bite at it

and Mr. Gordon would follow to deal with any points left uncovered. It was difficult to give a straight answer to much that speakers had asked. Dr. Sainsbury mentioned baffling. One of the earlier conclusions had been that it was difficult to devise a baffle that would operate efficiently and allow pigs out and in with reasonable ease. There were baffle doors that were so heavy that only the first pig got out! From the pigs' point of view that provided a most inefficient way for them to get out to urinate.

The modification of the verandah was a marked improvement. The existence of an open verandah tended to funnel the air into the opening and it was difficult to avoid floor draughts; and while the McGuckians tried a variety of baffle materials, the pig usually had the last answer. Efficient baffling under ordinary farm conditions was difficult to achieve and a built-up verandah was a very important modification of the present structure. Closing the verandah entirely in periods of very warm weather and opening everything else up gave a better control of the "camping out" tendency in which pigs tended to indulge in warm weather.

The idea of a "sleeper" was largely a first-aid measure. In Northern Ireland one seldom got an opportunity of "going to town" in designing a new piggery and the general tendency was to modify existing buildings as cheaply as possible, and it was felt the "sleeper" modification could be adapted to many existing buildings.

Cross ventilation was most important. Was fixed open ventilation conducive to draughts? Dr. Luke said that in that connection he personally was inclined to discourage mechanical devices. They tended to get out of order and the pigman tended to suit himself rather than the pigs which such devices were meant to satisfy. A tendency to draught was not found with the allowance of 3 sq. in. per pig.

As to whether virus pneumonia was present at the McGuckians' farm, it could be said that coughing pigs were heard there. One should not belittle the effects of virus pneumonia, but there was a saying about pigs "that coughed away and thrived away." Where environment was reasonable virus pneumonia was not the problem it could be in an inadequate environment. It could be said that virus pneumonia did perhaps exist at McGuckians, but its effects on the productivity of the farm had been modified by methods outlined in the paper.

Messrs. McGuckian would probably agree that a so-called McGuckian piggery costing £18,000 was out of their class altogether. The paper did not attempt to deal with new houses. As regards a possible accredited virus pneumonia-free herd scheme, Dr. Luke had no experience. With the tendency of the Irish farmer to have a deal now and again, one could foresee a difficulty in pigs going down the road to the next farm. There did not seem to be much future for such a scheme, certainly under conditions in Northern Ireland. He probably would not recognise Russian comtrey if he saw it, and therefore had no comment to make on that.

The relative unimportance of temperature compared with humidity had been mentioned. It was much easier to keep humidity down if temperature was high. The management at McGuckians was very good and pigs were in a shifting environment from birth. They could be moved about with comparatively little upset and the movement had little effect on their food conversion rates. As for the size of pens, perhaps all would agree that the smaller the unit, the better. One possible criticism was that the McGuckian pen was inclined to be too large and in a new design that factor would probably be taken into account. The question of grading according to the two environments had not been followed up.

Mr. Gordon, in reply, said that with regard to baffling the fronts of the two types of pen were identical. The inside structure of the pens differed in that one had two sleepers and the other had an open floor. The point made about ventilation was most interesting. Unfortunately it may not have been very clear from the paper, but the air flow which went up from the sleeper was 100 per cent. controllable and provided 3 sq. in. per pig. Professor Baskett suggested the use of fans to draw in air at the higher point which would seep out or be driven out by the velocity of air coming in. Such a form of ventilation deserved thorough investigation. Regarding permissible carbon dioxide as a criterion of adequate ventilation, Inglis and Robertson in their paper "Hygienic Aspects of Pig Housing," dealt with the value, or lack of value, of carbon dioxide for this purpose.

The paper was not altogether clear on the question of treatment rates. Where large numbers of pigs were being handled, as at McGuckians, it was impracticable to take steps to trace whether a pig had been treated twice or three times. A sick pig might require one treatment or it might require two or more. The treatment rate was not necessarily the sickness rate. The figure in the paper related to treatments administered and not necessarily to the number of sick pigs. Mr. Tweed would be able to pick up some valuable information on sow houses when at the farm later that day.

The Chairman said that the meeting had been very successful, very interesting and very profitable from the point of view both of the paper and the discussion. He would ask them all to accord a very hearty vote of thanks to Mr. Gordon, Dr. Luke and Dr. Sainsbury for their very useful contributions on the environment of pigs.

The Effects of Atomic Explosions Upon Animals

BY
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THE atomic weapon detonated over the city of Nagasaki was the equivalent of 20,000 tons of T.N.T. It has become conventional to describe weapons of this size as "nominal" bombs. The results of this and similar detonations have been given in some detail in a book, "The Effects of Atomic Weapons," published in the U.S.A. and sponsored by the United States Atomic Energy Commission and Department of Defence. As far as we are aware the domestic animals of the Japanese cities were not subjected to any particular examination, though the human population was, of course, studied as intensely as possible in the months and years after the event.

It will be remembered that the Nagasaki weapon was detonated high in the air. The reason for this was to obtain the maximum effect from blast. Consequently, in the human population of the city the majority of the casualties were attributable to the secondary effects of blast, falling buildings, flying bricks, tiles and glass. Thermal injuries and flash burns were also a major cause of damage. Of the casualties only about 15 per cent. were said to suffer from injuries due to the ionising radiations of the weapon. Blast caused casualties for a distance of up to five miles from the centre, heat and flash for a matter of some two and a half miles and radiation for about one mile.

There was nothing special recorded about the injuries due to blast and heat other than the very large numbers of casualties. From our general knowledge of blast and heat we can, we believe, anticipate the results of any other weapon as scaling laws can be applied for weapons of different T.N.T. equivalent with reasonable accuracy.

The biological effects of ionising radiation, however, are less widely understood. As recently as 15 years ago they were virtually the exclusive province of that rather limited speciality—radiotherapy. For the purpose of this paper, therefore, we will concentrate on the effects of ionising radiation.

X-rays, a form of ionising radiation comparable with the gamma radiation from a nuclear weapon, have been extensively used in experiments with mammals. All species of mammals are affected in much the same way. Results obtained in the laboratory with mice and rats can therefore be applied to the consideration of cattle, sheep, pigs and horses. General laws have been worked out mainly with the small mammal and confirmed in more limited experiments on the larger and more expensive animals. The median lethal dose of radiation for the mammalia varies from about 200 roentgens (the unit of dose for these ionising radiations) in guinea pigs to something like 800 roentgens in the rabbit. The ordinary domestic animals, as far as they have been investigated, fall within this range which is very small compared with the range of concentrations over which bacterial or chemical agents are toxic to different species. This convenient situation makes it fair to assume that something like 500 roentgens is likely to be the median lethal dose in a single short exposure for any of the animals which we need to consider. If a dose much greater than this be given the effect will be completely lethal. With supralethal doses of this sort the animal usually dies within a matter of days, mainly from a syndrome of dehydration and salt depletion probably associated with gross gastrointestinal damage which results in intense diarrhoea of a type refractory to replacement therapy. There is no point, therefore, in considering here these supralethal doses.

From a dose within the lethal range the animal exhibits a chain of symptoms which is conventionally known as the radiation syndrome. With man and dogs this involves three phases, the first phase being known as "radiation sickness." As the name implies the predominating symptom is of gastrointestinal upset with nausea and vomiting. There are also other symptoms the cause of which is far less well understood and the chief feature is a profound lethargy. Experimental animals on the whole do not show the gastrointestinal symptoms to the same extent as primates, but they do manifest the lethargy and this is usually associated with anorexia. With practice, therefore, it is possible to recognise in some experimental animals those individuals that have recently been irradiated with doses expected to be within the lethal range. This stage of radiation sickness is comparatively short, lasting some hours or at the most a day or so, following which the animal passes, as far as symptoms are concerned, into a latent state with good appetite and normal behaviour. Objectively, however, signs of damage are shown by an investigation of the peripheral blood. In spite of the absence of symptoms there is a progressive fall in the leukocyte count, usually affecting first the lymphocytes and subsequently the granular cells. By the end of the first week, therefore, with most species there is a profound leukopenia and at this time also the number of blood platelets begins to diminish. The higher the dose within this lethal range the shorter is the duration of this symptomatically latent period. The third stage is the clinical manifestation of the damage done to the radiosensitive tissues. This commences at a variable time, from one to three or four weeks after irradiation. The most important of the damaged tissues is the haemopoietic system. The aplasia of the bone marrow has of course

been present since the early hours, but is only declared clinically at this late stage.

There are two major causes of morbidity and death at this stage. The first is apparently due to the prolonged lack of leukocytes, perhaps associated with damage to the antibody-forming mechanisms. From the skin, the oropharynx and the gut there is an invasion of the body by the normal bacterial population through any spontaneous or artefactual break in the surface. The reaction of the normal animal to such invasion is of course the process of inflammation, but in the irradiated animal inflammation is notably absent and the response to this bacterial invasion is progressive necrosis. Thus, one may expect to find oropharyngeal angina, or farther down the intestinal tract, necrotic ulceration of the small and large intestines. There is often with this bacterial invasion a frank septicaemia.

The other major manifestation of aplasia of the bone marrow is haemorrhage—haemorrhage into the tissues, petechial or massive, and leakage of red corpuscles into the lymphatic system. This is often associated with a profound fall in the red cell count of the animal and this leakage of red cells from the blood into the lymphatic system is now considered to account for most of the red cell loss. Thus, at autopsy after death of an animal at this stage, death is usually attributed to progressively advancing sepsis or to haemorrhage. There may be other more profound and obscure reasons for death, but they need not concern us here.

If, on the other hand, the dose has not been too great the animal may recover from the delayed effects of radiation. However, the convalescence is long and it may be years with man and the longer-lived animals before full health is apparently restored. If the dose has not been overwhelming, the effects of the radiation on other systems are apparent in this stage of recovery. Reference has already been made to the radio-sensitivity of the blood-forming tissues and the intestinal mucosa. Two other notably radiosensitive tissues are the germinal epithelium and the skin. About two weeks after a radiological insult, injury to the skin becomes apparent by the falling out of the hair. This is a useful criterion of exposure to massive doses of radiation. In the course of time there is recovery of this tissue and the hair grows again, although in some cases the full pigmentation may not be restored and grey hair may be the result. The effects on the gonads can be investigated histologically by experimental biopsy; but in practice the effects are sterility or at the very least, grossly reduced fertility for a considerable period of time after the event. Ova are usually completely destroyed by a dose of about 500 roentgens and from this there is, of course, no recovery. The spermatogonia are the most radiosensitive cells in the testis and they disappear within a few days of the injury. The mature sperm are less affected. In the experimental animal, there is usually a period of about a week after irradiation in which conception can be effected; this is followed by the period of sterility. Spermatogonia are not usually permanently destroyed by doses of the order of hundreds of roentgens and they regenerate after a variable period of time. With the mouse, this may be a coup.e of months, but with man, and one suspects most large animals, it might well be several years. These effects on the skin and on the gonads will, of course, be notable even with doses which are well below the lethal level.

Long-term effects of radiation

Besides these sub-acute effects one must anticipate really long-term effects of a serious dose of radiation of the order of 100 roentgens or more. These effects are usually explained in terms of mutation. Mutations in germ cells will only appear in subsequent generations and need not concern us here when we consider effects manifest only in the individual. In the somatic cell the mutation is considered to be the cause of subsequent neoplasia either benign or malignant. In a matter of years after a large single dose of radiation to a group of animals one must expect an increased incidence of tumours. In man and the experimental mouse this mainly affects the haemopoietic system and leukaemia is one of the common sequelae. Amongst other tissues of the body which may be affected by radiation is the lens of the eye, and cataract following large doses of radiation is a well-known complication.

All the phenomena that have just been described are those to be expected from a single flash dose of ionising radiation applied externally to the animal, but affecting it because of the deep penetration of gamma radiation. It is necessary, however, to consider the effects of chronic exposure to radiation.

When a nuclear weapon is detonated there are two sources of radiation. There is an initial emission of neutrons, and a flash of gamma radiation caused partly by the fission of plutonium or a similar element but mainly by the immediate release of fission products. Most of the daughter elements formed by fission are radio-active. When an explosion occurs high in the air, as at Nagasaki, these radioactive fission products are carried with the thermal draught into the upper atmosphere as a fairly particulate cloud and are enormously diluted before they ultimately settle. If, however, the weapon is detonated not high in the air, but low down where the fireball touches the earth, or even on the ground, there will be a great scouring of the superficial dust and earth with which the fission products will have been intimately mixed. Much of this rubble will then be "thrown out," the larger debris will be deposited locally down-wind as "fall out".

An even worse condition of local deposition of fission products would occur if the weapon were detonated subterraneally or in water. Apart from the greater localised deposition such bombs may yield fission products of much greater solubility than the products of air bursts. This can result in a much greater entry of the fission products into biological systems. We have therefore got to consider the radiological effects of the

throw-out and the fall-out of this great mass of radioactive material.

In the process of fission the plutonium or other fissionable atom does not split into two equal halves. The two daughter products of the original atom tend to be of unequal size and it is now predictable how much of any particular fission product will be formed. In general, fission products with a mass number of about 95 and 140 are most abundant and the graph of the fission yield of atoms against mass number is bimodal with the maxima at mass numbers of 95 and 140.

The radioactive fission products are extremely unstable and contain an excess of neutrons over protons. Greater stability is obtained by the conversion of a neutron to a proton and in the process the atomic nuclei emit negatively charged beta particles and often of gamma rays as well. One such disintegration seldom restores stability to the nucleus and the emission is repeated three or four times before a stable atom is eventually formed. Thus for each mass number we have what is known as a fission chain. In the case of the mass number 89, for instance, we have ^{89}Krypton formed originally, which decays by the emission of a beta particle to ^{89}Rubidium, which in turn decays to ^{89}Strontium, which decays to stable ^{89}Yttrium. In general, the farther to the right of the chain the nearer is the atom to stability and therefore the early atoms in the chain tend to decay much more rapidly than the later members. The combined results of this gradually declining decay rate in a large number of fission chains means that there is intense radioactivity to begin with, getting progressively less and less with time. Empirically this can be expressed by a formula: A_t (the activity at any time t)$=A_1$ (the activity at unit time) $\times$ $t^{-1.2}$. If we take t as being in minutes, then it follows that at 10 minutes after burst the activity will be less than one-tenth of the activity at 1 minute and at 100 minutes after burst it will be considerably less than one-hunredth of the activity at 1 minute. Therefore, by the time that the distant fission products fall out a great proportion of the activity will have already decayed and in a consideration of the chronic effects of radiation it is the longer-lived elements of these fission chains which are important.

Effects upon animals

First of all let us assess the effects on animals that might be some miles down-wind from an explosion of the type where fall-out is a major hazard. The fission products will fall on the coats of the animals if they are in the open and also on the surrounding earth. The animals will be exposed to the gamma radiation of these fission products in the environment and these gamma rays are, as we have noted, intensely penetrating. Animals in shelter such as barns will be spared the effects of direct deposition of radioactivity on their coats, but they will still be exposed to a fraction of the penetrating gamma rays from outside. There will, however, be a factor of safety in distance from the source and in absorption of some of the gamma rays by the walls, particularly if these are brick rather than wood. If fission products are deposited directly on the coats, the skin may well receive superficial radiation burns from the poorly penetrating beta particles. However, the chief effect is considered to be from the gamma rays. An extended exposure to a low intensity of this radiation will produce much the same damaging effect as a single exposure to an intense gamma ray flash, though an initial phase of "radiation sickness" is not to be anticipated. In an area of considerable fall-out, therefore, the major hazard is from this external radiation.

Still further down-wind, however, the fission products will be sufficiently diluted for the external dose of beta and gamma radiation received by animals or man to be well within tolerable limits. A new hazard has now to be evaluated, namely, the possibility of internal contamination of the body with radioactivity. It is the habit of grazing animals to derive their food from wide areas—perhaps some tens or hundreds of square yards of pasture per day. Thus, as the grass is particularly retentive of small particles, of which the distant fall-out consists, the animals will take into their intestinal tract the deposition of radioactive materials from a wide area. We have, therefore, to consider what the effect of this ingestion of radioactive material will be upon the gut of the animal and upon the internal organs if the materials are absorbed. By and large, if the weapon has been detonated over dry land, so that soil is caught up with the fire ball, the fission products are intimately mixed with the volatilised silica and the solubility in water of the resulting condensate is low; but the smaller the particle size the more likely it is that the contained fission products will be soluble. The gut, moreover, has the ability to extract some materials of low solubility from food.

We must therefore consider the fission products as individual elements and we find that the long-lived ones formed in reasonable abundance are as in the following list:—

When these fission products are administered to animals experimentally in a soluble form it is found that only a certain number of them are taken up from the gut to any appreciable extent and these are Strontium, Ruthenium, Tellurium, Iodine, Caesium and Barium. The rare earths, which contribute so many of the long-lived fission products, and the trivalent and quadrivalent elements are in general not absorbed from the gut.

It is considered that the two elements which would give rise to the greatest hazard are iodine and strontium, iodine because it is taken up and concentrated in such a small organ as the thyroid gland, strontium (and to a lesser extent barium) because it is an alkaline earth and will behave metabolically in a similar fashion to calcium. These radioactive elements emitting β particles

PRINCIPAL NUCLEI FORMED IN FISSION

Nucleus	*½ life*	*Decay*	*Fission Yield*	*Energy of radiation—Mev* β	γ	*Radio-active daughter*
^{85}Kr	10 y.	β	~ 0·24	0·7	—	—
^{89}Sr	53 d.	β	4·6	1·5	—	—
^{90}Sr	20 y.	β	~ 5·0	0·6	—	^{90}Y
^{90}Y	62 h.	β	~ 5·0	2·2	—	—
^{91}Y	57 d.	β	5·9	1·54	—	—
^{95}Zr	65 d.	βγ	~ 6·4	0·4	0·8	^{95}Zr
^{95}Nb	35 d.	βγ	~ 6·4	0·15	0·75	—
^{99}Te	$2 \cdot 10^5$y.	β	~ 6·0	0·3	—	—
^{103}Ru	42 d.	βγ	3·7	0·2	0·5	—
^{106}Ru	1 y.	β	0·5	0·04	—	^{106}Rh
^{106}Rh	30 s.	βγ	0·5	3·5	0·5 +	—
$^{129*}Te$	32 d.	I.T.e⁻	0·2	—	0·1	^{129}Te
^{129}Te	70 m.	β	0·2	1·8	0·3 +	^{129}I
^{129}I	$1.7 \cdot 10^7$y.	βγ	0·2	0·1	0·04	—
^{131}I	8 d.	βγ	2·8	0·6	0·36 +	—
^{137}Cs	33 y.	βγ	—	0·5	0·7	—
^{140}Ba	12.8 d.	βγ	6·1	1·0	0·2 +	^{140}La
^{140}La	40 h.	βγ	6·1	1·4	1·7 +	—
^{141}Ce	33 d.	βγ	5·7	0·4	0·15	—
^{144}Ce	275 d.	β	5·3	0·3	+	^{144}Pr
^{144}Pr	18 m.	βγ	5·3	3·0	+	—
^{147}Nd	11 d.	βγ	2·6	0·8	0·1 +	^{147}Pm
^{147}Pm	2.3 y.	β	2·6	0·2	—	—

of poor penetration cause an intense ionisation in their immediate neighbourhood, leading to death of tissue as an acute effect or to neoplasia as a chronic effect.

There are many short-lived radioactive iodine fission products, but there is one, ^{131}Iodine, which is formed in considerable abundance and has a half-life of eight days. Therefore, in the period immediately after burst probably the greatest hazard to grazing animals down-wind may be from the possibility of ingesting considerable quantities of this radioactive iodine. Its absorption is virtually 100 per cent.; much of it is excreted in the urine, but about 20 per cent. will be bound in the thyroid and a small percentage will be excreted into the milk. Later on in time the hazard both to the animal itself and to any potential drinker of the milk is likely to be from the radioactive isotope of strontium, ^{89}Sr. This is absorbed to a variable extent from the gut, perhaps 25 to 50 per cent. depending upon the age of the animal. A fraction of this, perhaps a half, may be deposited in the bone where most of it is retained tenaciously. Again, a small percentage is secreted in the milk, probably 1 to 2 per cent. of the material taken in if the animal is on a high calcium diet. It can be calculated, assuming mixed fission products to be reasonably soluble, that doses which constitute a hazard to the cow consuming them, are approximately equally dangerous to the infant who drinks the cow's milk. With fission products of low solubility the hazard is predominantly to the cow's digestive tract.

With the passage of time fission products will enter the plants from the soil by absorption through their roots. Fission products absorbed from the soil will in fact be diluted by other ions entering the plant. Thus, the hazard will be considerably less than that which occurs when fission products are deposited directly on leaves. None the less, in limited areas the contamination of the soil with ^{90}Sr, the long-lived radioactive isotope of strontium, may eventually become the limiting hazard.

These considerations prompted one to ask the question, "Over how big a zone may the effects of fall-out be significant?" No simple answer can be given. It has already been pointed out that the hazard of fall-out is very slight when atomic weapons are detonated considerable distances above the earth's surface, as was the case at Nagasaki. On the other hand when weapons are detonated at or near the ground surface, radiation effects may be of great magnitude. The extreme

case of which we at present have knowledge is the so-called H-bomb test of March 1st, 1954. This device was detonated on a coral islet in the Pacific, and it is presumed to have been a surface burst. The area in which fission products fell out in such quantity as to give a mammalian lethal dose of gamma rays was stated to be about 7,000 square miles. This was of course far more extensive than the area over which blast and heat would have been lethal. It can be concluded that the area peripheral to this lethal zone which would be hazardous for domestic animals was yet greater. This emphasises that, depending on the conditions of detonation, the biological consequences are variable in the extreme. In considering the action which would be taken in the face of any such catastrophe the rapid decay of fission products is to be borne in mind. Any measures which delay the exposure of animals to the deposited material, even for only a few hours, will significantly reduce injury in the early period.

Summary

From the atomic weapons exploded in the air at Hiroshima and Nagasaki there was only a small proportion of casualties due to ionising radiation. Weapons exploded on or near ground or in water could give a different pattern. The biological effects of γ radiation in particular are therefore outlined. All mammals react in much the same way. The median lethal dose is some hundreds of roentgens. With doses greater than this, death is due to disturbances of water and electrolytes in the body. Near the mid-lethal dose the main danger is to haemopoietic tissue—aplastic anaemia is the apparent cause of early death, leukaemia of delayed death. Effects on germinal epithelium, lens of the eye and skin are also notable.

Fall-out of radioactive material under these postulated conditions could also lead to internal as well as external radioactive contamination of animals. Grazing animals are particularly at risk. The individual long-lived fission products and their localisation within the body are discussed. Strontium and iodine are considered to be the most critical elements. Both are secreted in milk and thus are a hazard to man.

With H-weapons as exemplified by the 1954 tests at Bikini the hazards from "fall-out" are many times greater.

THE SPEAKER'S INTRODUCTION

The Chairman, Dr. W. R. Kerr: "This morning we have a paper entitled 'The Effects of Atomic Explosions upon Animals.' I wonder what it would have been like 20 years ago if at the Congress of 1935 such a title had appeared on the agenda. This morning we have Dr. Scott Russell on behalf of Dr. Loutit and himself—both of them international figures—to give us this paper. 'Climaxes and anticlimaxes' is a masterly understatement. He finishes his paper by saying: 'The area in which fission products fell out in such quantity as to give a mammalian lethal dose of gamma rays was stated to be about 7,000 square miles.' What a climax!"

Dr. Scott Russell (Oxford): "When we received the flattering invitation to take part in your conference, I regretted greatly that unavoidable circumstances would make it impossible for Dr. Loutit to be here, for not only is he my senior partner in the work we are doing in this field—work in which we enjoy and depend upon the collaboration of some of your colleagues in England—but also he has a long experience of work with experimental animals while I am concerned primarily with plants. But it would be untrue to say that Dr. Loutit's absence has no advantage from my point of view; I have so greatly enjoyed the opportunity of meeting you all.

"In our paper we have attemped to summarise some of the broad principles which have at present been elucidated with regard to the biological effects of atomic weapons."

Dr. Russell then summarised the main points in the paper by Dr. Loutit and himself.

The Opener

Major J. H. Wilkins (R.A.V.C., Aldershot): "I feel highly honoured to open this admirable and succinct paper by two eminent scientists. In spite of what I shall say later, I believe the country in general, and the veterinary profession in particular, are indeed fortunate that these two internationally famous radio-biologists have interested themselves in the applied effects of atomic explosions upon the domestic animal. When I was first asked to open this discussion some months ago I felt that no better person could have been chosen, and that for three reasons:

(i) It is about animals, and I am a veterinary surgeon;

(ii) The subject, in spite of the recent party at Geneva, is still essentially military, and I am in the Army;

(iii) The subject is the exclusive field of the expert, and although I am certainly not one of these, I have been actively interested in this subject for ten years and have attended some half a dozen courses, Army, Navy, Air Force and Home Office, and know and understand the jargon.

"So I suppose you might call me a clued-up non-expert military veterinary surgeon if you like. I can think of no better combination for an opener.

"However, when things began to get nearer the day and I received a copy of the paper I realised how formidable was my task if I was to do it justice. The General Secretary's warning to me to restrict my remarks to 20 minutes seemed to have a mocking air about it. It was an eternity of time in which to step on sensitive radio-biological toes. I am sure that if I accidentally do so I shall be forgiven, and if at the same time I appear to read my address I shall be excused, for it is dangerous for one such as I to enter this dialectical labyrinth without great caution. How much more caution, however, is needed from a medical scientist on the one hand and an agricultural scientist on the other from standing on the infinitely more sensitive toes of a galaxy of veterinary surgeons morally strengthened by numbers—especially when they dare to talk about animals!

"Colonel Rust of the United States Army Veterinary Corps in a lecture at Harwell in April of this year stressed the importance of avoidance of panic by arriving at a correct diagnosis of radiation sickness in animals in areas where there was a likelihood of a fall out of fission products after the explosion of a thermonuclear device. Signs which may be considered important or diagnostic to laymen may not be so vital in the field, and the differential diagnosis cannot be extrapolated (as they say in the United States) by all the wise men in China unless they happen at the same time to be graduates or doctors of veterinary medicine. Just as the law demands the best evidence, so let us ensure that we get the best available data from radio-biological work on the domestic animals and foodstuffs of animal origin. We must ensure that the authorities recognise that however many ancillary scientists come in to help us, that the direction and general interpretation stays in the hands of the expert, *i.e.*, the veterinarian.

"Recently, Field-Marshal Lord Montgomery in lectures in this country and the U.S.A. has given us a broad outline of the next war. From these lectures it is possible to let one's imagination work to try to picture what the first few hours, days, and months of the next war will look like.

"First of all there will be a surprise air attack from the East without any alert or even tension. There will be no build-up or ultimatum; our first warning will be the arrival of Fantasian bombers.

"Next we shall have the great air battle, offensive and counter-offensive, during which two strategic air forces will hurl thermonuclear, atomic and conventional bricks at each other and at each other's territories; both sides struggling to gain air supremacy and to eliminate the other at one blow. Unfortunately, in this duel, as we shall not be the aggressors, the Fantasians will have the initiative. Do not forget, he is twice armed who gets his blow in first, especially with atomic weapons.

"Great Britain will suffer considerable devastation especially in and around airfields, ports and where industry is concentrated. There is no question or doubt that large areas of the countryside will be affected and large numbers of animals both large and small will be killed and injured by heat, blast, burns, and radiation. The later 'fall-out' effects of fission products will become so serious in the case of thermonuclear weapons that it is doubtful whether the country will effectively survive if more than a few of these devices are exploded.

"I have recently seen again the films showing the explosion of the 'A' and 'H' bombs. It is indeed a terrifying spectacle and brings the whole problem into perspective.

"It is my belief that these films should be seen more frequently by the general public so that they can orientate themselves. The first thoughts that enter a normal person's mind after seeing these films is 'Nothing can survive.' In fact, it is not as bad as it looks for by taking suitable precautions we can survive, unless we are unlucky to be in the killing zone.

"It is our duty, in spite of what we think, to learn all we can about this dreadful business because, unfortunately, the problems cannot be handled by a few experts or volunteers. Trained and disciplined men will be needed to act under good, knowledgeable leaders.

"What will be the rôle of the veterinary services in this Armageddon? I believe that in the veterinary and medical professions the utter futility of pretending that it would be possible to offer effective aid to more than a handful of patients is very real. We must plan realistically and put away all selfish ideas. Nevertheless, I do not believe we shall have much time nor inclination to worry over other people's troubles. The main functions of a veterinary surgeon in the event of this catastrophe should, I venture to say, be in this order of precedence:

(i) To help the doctors to save human life and to treat human casualties if necessary;

(ii) To advise on the disposal of animals (transport and food animals), which will become a serious sanitary problem;

(iii) To take over the overall supervision of the inspection of food of animal origin and to organise a monitory service in this connection;

(iv) To advise agriculturists;

(v) To treat animal casualties.

"So much for my introduction. Now for the frothy middle-piece. I intend to confine my remarks to some theorising and questions on:

(i) Whole-body irradiation;

(ii) Internal radiation;

(iii) Genetic effects.

External Whole-body Irradiation

"Our knowledge of the applied effects of radiation on the mammalian body are derived from three main sources:

(i) Animal experiments and accidents;

(ii) Chronic effects on mammals including man, exposed to small doses over long periods;

(iii) Acute human and animal casualties at Hiroshima and Nagasaki. In this connection the author states: "As far as we are aware, the domestic animals of the Japanese cities were not subjected to any particular examination." I must draw the attention of the authors to an article in *The Journal of the American Veterinary Medical Association* of April, 1951, entitled 'Immediate Effects of the A-Bomb on Jap Army Animals with the Hiroshima Division.'

"Studies on the biochemical effects and on protection have, for the most part, been carried out on rodents. The dog is the animal in which reaction to ionising radiations are most akin to those found in man. So our faithful friend is once more helping us out of our ignorance.

"So far as I know no experiments have been carried out in the U.K., nor is there any information on effects in this country, on horses, bovines and pigs. This will no doubt be shortly rectified when the radio-biological units at Compton begin to function.

"One of the most mystifying things about nuclear radiation is the extraordinary way different species of animals vary in their general sensitivity. Man comes between the monkey and the mouse as far as radio-sensitivity is concerned; the poor rabbit in this sense is twice as tough as man. Why should one type of animal cell need 4,000,000 times as much radiation to kill it as another type, to quote extreme cases? Another curious fact is that mammals are more radio-sensitive than either cold-blooded fish or hot-blooded birds. It is understandable why the cold-blooded should be less sensitive but why is the domestic fowl, with a higher body temperature and metabolism than the dog, five times less sensitive to nuclear radiation? The whole story reminds one of the viruses. Can it be that we must look more for a biochemical reason and tend to discard the biomechanical explanation given for the physiological effects of irradiation on cells?

"Is it a question of internal cellular environment, especially oxygen tensions, which allows one cell to die and another to live? Or is it more fundamental, and does radio-sensitivity depend upon the number of chromosomes in the cell nucleus make-up? If so, one method of producing a race resistant to radiations would be to increase the number of chromosomes!

"The authors state there are four phases in the radiation syndrome in man and dog:

Phase 1—Radiation sickness;

Phase 2—Latent state;

Phase 3—Clinical manifestation of damage done to radio-sensitive tissues.

Phase 4—Late effects.

"They also state that all species of animals are affected in much the same way and that results obtained with mice and rats can be applied to cattle, sheep, pigs and horses. With due respect, I think this view, which itself is an extrapolation from other biological sciences, is erroneous and unscientific. As far as animals are concerned, to quote but one example, the effects on the haemopoetic system of rats and mice compared with other animals is quite different, and the same may apply to other systems and organs.

"I firmly believe that this is one science where it is indeed dangerous to work on analogy.

"I have seen another tabulation of the general effects of radiation on dogs in three phases. This may be of more use to veterinarians:

First stage of irradiation: Shock (due to increase of permeability of capillary endothelium);

Second stage of irradiation: Haemorrhages, infection, anaemia, malnutrition;

Late effects of irradiation: Prolonged sterility, cataract, leukaemia.

"After an atomic attack the slightest wound in an animal will become a serious problem owing to the loss of ability to form antibodies, tendency to haemorrhage, and malnutrition. Would antibiotic treatment be the answer or would local treatment suffice? Should we give it as soon as possible or wait for a few days? Is there any connection between the leucocyte count, resistance to infection and survival?

"What is a good prognostic sign as far as blood examination is concerned? Can transfusions of blood save the life of an animal which has received the usually considered fatal dose of 400 to 500 roentgens? Is forced feeding of any use to counter the anorexia of radiation sickness?

"What indeed is the pathogenesis of radiation sickness? Is it a generalised syndrome due to lesions at one focus or is it in fact a series of lesions with local clinical signs? The initial symptoms are not unlike the signs of normal physiological adrenal alarm action. Is it in fact possible to explain the total effects of irradiation as a series of biochemical

lesions, and, if so, is there a possibility of finding a complete cure for radiation sickness and its sequelae? I should like to hear the authors' opinions in connection with the three following possible applications of chemotherapy against the effects of whole-body radiations on the animal body:

(i) The administration of substances like cystamine before an expected exposure to nuclear radiation to act as a biochemical protector;

(ii) The administration of substances like BAL to reverse the principal biochemical changes;

(iii) The administration of spleen and bone marrow to assist in the regeneration of the blood-forming organs.

"With regard to the sensitivity of different tissues to irradiations, it is said to vary in direct proportion to their reproductive activity and in inverse proportion to their degree of differentiation. This means that germinal epithelium, lymphatic tissue and bone marrow are the top three most sensitive, whilst nerve, brain and muscle are the bottom three. I have read that the first symptom produced in a fatal accidental massive irradiation of a nuclear physicist at Los Alamos was nervous. Is this paradox explicable and is nervous tissue more sensitive than we have believed up to now?

"The gastro-intestinal system is sensitive and provides diagnostic symptoms. Is the vomiting and diarrhoea due to inactivation of enzymes, production of toxins or destruction of cells? Have tumours ever been noticed to arise in this system due to irradiation?

"The effects on the skin and coat are quite definite, in man. Is there a regular pattern of epilation in animals? Do the follicles atrophy? Is there any prognostic value in this? I believe that there has been an over-emphasis of the importance of ionisation in radiation processes in biological tissues. The possible influence and far-reaching effects of radiationless excitation and remote transitions in other parts of the body following radiation should be given more prominence. Do the authors agree, and, if so, is it not necessary to reassess the whole question of dose and dose rate, tolerance doses and threshold values?

Internal Radiation

"So far I have confined my attention to external and gamma radiation and have ignored the effects of alpha and beta particles because of their short range. When, however, this radiation comes from a source inside the body the circumstances are quite different. A radioactive substance which has been absorbed and fixed in the animal body is an insidious but deadly poison. At least a few milligrammes of the most powerful chemical poisons like prussic acid are needed to prove fatal, but the fatal dose of some radioactive substances need not be more than 1/10,000th of that amount.

"We know that radioactive material may be absorbed into the animal body by ingestion, inhalation, or injection. The authors state that the greatest initial hazard to animals downwind is the ingestion of iodine^{131}, and that later on in time strontium^{90} becomes the most dangerous hazard to cattle and to drinkers of their milk. What is the time limit of this hazard? Does the half-life of eight days and 53 days respectively imply that the hazard from each of these radio-isotopes disappears or is reduced to infinitesimal amounts in this time? Surely the time depends not on the half-life but on the concentration of radio-isotopes for, theoretically, there will be some emission of alpha and beta particles to infinity. May the hazard from iodine^{131} be more from inhalation than from ingestion? Another inhalation hazard is carbon^{14}, with a long half-life of 4,000 years. Some people consider it one of the most dangerous of the radioactive isotopes produced, as it is volatile and (as CO_2) is a source of carbon for plants and is thus directly incorporated into the animal body. Why have the authors not mentioned carbon?

"Is it possible that solid radioactive particles (in contradistinction to the volatile substances like carbon^{14} and iodine^{131}) may play a more important part by being inhaled or injected into the orifices other than by ingestion? What size of particles are stopped in the respiratory tract and find their way into the alimentary tract? What happens to those particles which get into the alveoli of the lungs?

"In a recent speech Dr. Libby, of the U.S.A. Atomic Energy Commission, stated that the fission products in 'fall-out' comprised 34 different chemical elements, of which the most dangerous was strontium^{90} with a half-life of 20 years. The activity of strontium^{90} from an H-bomb explosion per square inch in an area of 7,000 miles is between 1.2 and 1.5 micro-curies. The maximum permissible dose of strontium^{90} in the body is 1 micro-curie. So it appears to me that strontium^{90} is going to be the universal limiting agent to the whole business. Three cheers for strontium^{90}!

"The radiostrontium, we know, may enter the body in two ways:

(i) Directly, by cattle and other animals eating the plants on which it was deposited or

(ii) Indirectly by being deposited in soil and then being taken up and incorporated in the plant tissues which are eaten by the animal.

"We know that the metabolism of strontium is similar to that of calcium being readily absorbed and deposited in the substance of the bone. It is less readily absorbed by old subjects than by young and its absorption can be hindered by a high calcium diet. I understand that it can be 'washed out' by feeding a low calcium diet combined with thyroid and ammonium chloride. Do the authors agree with this finding?

"Could the immediate danger to animals from grazing on contaminated ground be countered by hand feeding? This would imply housing or, if left out, some form of muzzle to prevent them from grazing. Would hosing of the animals be sufficient to wash off the radioactive fission products adhering to the skin? We have been told how efficient the grazing cow is in collecting the radioactive substances from pastures over a wide area. Would the milk be dangerous for long? Should I be uttering a scientific untruth if I said that a cow would not react to tuberculin after irradiation?

"How would the pastures be brought back to healthy productivity after a ground burst? What would be the probable length of time?

"If a farmer asked a veterinary surgeon whether his farm was dangerously contaminated by 'fall-out' or not, could he be in a position to be firm and categorical? In this connection, could the pigs and other animals be sent to the slaughterhouse and would the meat be fit for human consumption? I ask this because cesium^{137} was found to be retained in high concentration for a long time in muscle tissue and this fact makes the eating of the meat appear to me to be a real hazard. Some people say that the danger of the not-so-soluble and insoluble fission products in the gut have not been credited with the importance due to them. They state, in fact, that the danger is directly proportional to their metabolic accumulation.

"We are told that most tissues can receive a small dose of nuclear radiation without any noticeable effect. That is to say there is a threshold below which no damage is sustained. The whole system of tolerance doses is based on the belief that if we keep the dosage rate below this threshold no harm will be done.

"There are, I maintain, some tissues for which there is no threshold. The damage in these tissues increases directly with the dose however small. Non-threshold effects are rare but surely they may become less so if our methods of detecting damage become more sensitive, and then we should have to change the whole question of our threshold. If our methods of detecting damage become more efficient, should we have to change the whole idea of tolerance doses?

Genetic Effects

"This, naturally, brings me to the genetic effects of nuclear radiation. Although this aspect of the problem was left out by the authors yet I know it holds a fascination for all of us.

"There appear to be two main viewpoints; the pessimistic attitude of geneticists is in marked contrast to the unjustifiably optimistic attitude of radio-biologists who state that man and the higher animals are not very sensitive to the mutogenic action of ionising radiations. At present there are two lines of evidence on which to base an estimate of the number of mutations produced by radiations:

(i) By analogy from animal experiments (extrapolation)
  (a) using the fruit fly, as Muller did, or
  (b) the mouse, on which Russell experimented;
(ii) By study of the effect directly
  (a) on survivors of Hiroshima and Nagasaki and their progeny
  (b) on the progeny of radiologists.

"According to Macht and Lawrence (1955) there is a small but statistically significant increase in congenital malformation amongst children of radiologists.

"There is a very real danger in working on analogy and extrapolation in this field for two potent reasons :

(i) The effect of radiation on nuclear material of cells (chromatin and chromosomes) is cumulative and there is no threshold. That is to say that mutations are produced however small the dose and however slowly it is received; 50 roentgens are equally dangerous if received in five minutes, in five years or in 25 years, and

(ii) Mutations are almost invariably unfavourable.

"Dr. Loutit, at Geneva, said something about the mutations being affected by environmental changes. New mutations may be the repetitions of the old which nature has tried before but, nevertheless, they must always be deleterious even when the environment changes. This is because if perchance they become potentially favourable on account of environmental changes yet because of civilisation as we know it nothing wilfully can be done about it.

"In animals we have stock breeding methods, but what Hitler tried to do on a small scale could not be stomached either by scientists or lay people. Besides, who is going to decide what the ideal human being is to be like and what are we doing to-day about favourable mutations which may or may not appear?

"The general effects of radiation on cells are of two kinds. Gross deficiences and inversions are *lethal* whereas small deficiencies and excitations may give rise to *mutations*. The two kinds of change have a very different importance in somatic body cells and in germ plasm.

"Most viable mutations are recessive and will not be noticed in the phenotype. As, however, the use of radiations has been increasing for over 50 years, the chances of two recessive genes coming together increase every day. It is not likely that any increase in deleterious mutations will be noticed in the immediate future but the time they begin to appear will vary directly with the amount of radiations being used, and it is obvious it is likely to increase when nuclear power becomes a reality. To our certain knowledge there has been no change in human germ plasm for 100 generations and probably very little in 1,000, which takes us back to the old Stone Age. We certainly seem to be playing with fire! Perhaps we may yet throw up a race of centaurs, half man and half horse, who will no doubt carry on the traditions of veterinary medicine and science with a more subjective air.

"I should like to end on a platitudinous note. We must try to apply to the problems of war the same mental approach as we do to animal disease. There is a resemblance between human behaviour and the dominant relations of animals. But there is not much fun in being top dog these days. Mankind is now in the exhilarating position of having the threat of nerve gases, bacteriological warfare and H-bombs over it. Unless we can control the biological human urge to be top dog or save face we may certainly be heading for the last round-up—doggies and all!"

The General Discussion

Dr. A. T. Elder (Belfast) said that, as a student of social and preventive medicine, he was interested in anti-biological warfare rather than anti-atomic warfare. His question had a bearing on a problem which arose every time there was a course in London or Belfast. In dealing with catastrophies involving thousands of people and animals, in the main, only simple remedies were possible. Would boiling milk or cooking meat in any way destroy the potential dangers of fission products?

Mr. J. N. Ritchie (Surbiton) said that this subject was an extremely valuable one to air at the Congress and it would be quite unfair to Dr. Scott Russell to prolong the discussion because he already had to range over most of the sciences before he could reply to the previous speakers. The questions that one might ask were simple questions. In the opening of the discussion, Mr. Ritchie was struck by the remark that there would be no warning and yet the meeting was asked whether there were certain preventative actions which could be taken. The two things did not seem to be reconcilable. From what he had been able to read and hear of the problem, he was quite satisfied that the situation which would face veterinary surgeons was far more concerned with the salvage of the animal product than with the attempted cure of animals which were already involved.

Major Wilkins had referred to differential diagnosis and Mr. Ritchie had been associated with Professor Boddie in the investigation of the mass effect of material deposited from smoke clouds, which apparently affected grazing and had a considerable adverse effect upon stock in an area in Central Scotland several years ago. It had nothing to do with atomic warfare but they were suddenly faced with the serious difficulty that no matter what was wrong with an animal in that area, it was always associated with this particular episode. He was perfectly satisfied that if any such incident of a much greater size took place, it would be extremely difficult to convince a farmer that anything wrong with his farm was not associated with that incident. One extraordinary example was where a farmer maintained that none of his mares could have any foals. There was a simple, biological answer, namely, that they had never been been sent to the horse. He seriously made the point that one need not be too fussy about differential diagnosis in such circumstances.

The problem to be faced was how to salvage meat and how to be satisfied that what milk was available was safe. It seemed likely that the problem would be more of organisation, if such was possible under the circumstances, than of meticulous differential diagnosis.

He concluded by saying how grateful he was to the authors for putting this subject forward and to Major Wilkins for his opening.

Mr. T. W. Groves (Manchester) said there was considerable interest in the use of radiation for the sterilisation of foodstuffs and pharmaceutical products. It had been said that small wounds would become very important after an atomic or thermonuclear explosion because of the lack of antibody protection. He suggested that at the same time as radiation affected the organisms with which we were concerned (animals), it might also adversely affect the organisms which infected domestic animals. Was there any possibility that the effects from secondary infections might be modified in some way?

The Reply

Dr. Scott Russell, in reply to the discussion, asked for a sense of proportion in considering the effects of atomic weapons : this was the more necessary because of the many ill-informed statements which had so frequently been made.

Referring to Major Wilkins's suspicions regarding tolerance levels he remarked that in the report of the International Commission for Radio-biological Protection (Supplement 6 to the *British Journal of Radiology*) there was no mention of "tolerance levels." The phrase used was "maximum permissible levels." In considering them it was most important to realise that the effects of radiation on the living organism is not a new phenomenon. The natural background was readily measurable and highly variable. Between London and some parts of the West Country or Sweden it varied by a factor of two to three. The natural backgrounds to which we are exposed were also varied by wearing wrist-watches which emit radiation from their luminous faces and by gathering together in halls when the naturally occurring radioactive potassium in other people contributes to the dose we receive. In short, we are always exposed to radiation, always had been, and always would be. "Maximum permissible level" meant the level which, in the light of present knowledge, did not appear likely to do any measurable harm; considerable safety factors were incor-

porated in the calculation. It was a realistic basis. The geneticists were not found on one side with the radiobiologists on the other as had been suggested by Major Wilkins. The recent discussions on genetics at Geneva, which were reported very accurately in the British Press, had shown that those geneticists who had wide knowledge of population studies considered that no one was in a position to make categorical statements at present.

It had been said by Major Wilkins that the study of the progeny of radiologists and of the after-effects of Hiroshima was the way to obtain information on genetic effects. A better way would be to undertake large-scale international surveys to see if any clues could be found from the progeny of populations who for centuries had been exposed to levels of natural radiation varying by these quite large factors from place to place.

Major Wilkins had not approved of Dr. Loutit and Dr. Scott Russell saying that, by and large, the doses of external radiation which were toxic to all types of animal were in the same general order and had mentioned a factor of 1,000 or 1,000,000 but that was comparing bacteria with animals. As could be seen from the paper, there were variations of a factor of 3 to 5 between the median lethal doses for different species. However, when it was borne in mind that the total dose rates individual animals or men had received would not be calculable with precision in time of war it was rational for the purpose of civil defence to ignore such intraspecific differences.

Referring to Major Wilkins's remarks on the biochemical effects of radiation Dr. Scott Russell remarked that this subject was receiving considerable attention but no practicable means for protecting large populations from these effects had yet been found. Similarly, the present data indicated that once fission products, for example, strontium, were deposited in the skeleton it would not be possible to accelerate their removal by a large factor.

Reference had been made to different isotopes and Major Wilkins had queried the fact that the ingestion hazard was greater than the breathing hazard. It had been shown at the discussions in Geneva that radioactive iodine in the atmosphere caused hazard to animals through grazing to be greater than that due to breathing by a factor of approximately 1,000.

Major Wilkins had referred to Dr. Libby's work with strontium^{90}. There were two isotopes of strontium, strontium^{89} with a half-life of 53 days and strontium^{90} with a half-life of 25 years. The amounts of the two isotopes produced by a nuclear weapon could be taken as inversely proportional to their half-lives. Turning 25 years into days and dividing by 53, it could be seen that vastly more strontium^{89} than strontium^{90} was produced and it had been widely agreed that for some time after an explosion the skeleton would receive a larger dose of strontium^{89} than of strontium^{90}. Dr. Libby's remark, under the circumstances in which he made it, was absolutely true: strontium^{90} was the dominant *long term* hazard. It appeared, however, beyond doubt, that the isotopes of iodine and strontium^{89} were the principal sources of ingestion hazards soon after the explosion of a bomb. Dr. Loutit and he had not referred to carbon^{14} which Major Wilkins had mentioned, because its effects would be trivial by comparison. A speaker had enquired about the effects of boiling contaminated milk. Its strontium content would be unaffected; an element could not be destroyed and the rate at which it decayed could not be accelerated. It could be argued that by boiling milk a little of the iodine in it would be driven off, but the percentage would be so small that in times of stress it would be better to save the fuel for other purposes.

The sterilisation of foodstuffs had been mentioned. This was at present a subject of considerable research. Very efficient surface sterilisation could be brought about by high levels of radiation and a technique of surface sterilisation with soft radiation was now being investigated which did not affect the interior of the food at all.

Summing up Dr. Scott Russell said that he had tried not to conceal the fact that present knowledge of the biological effects of nuclear weapons was small; there was much speculation. But even when much information had been gained by research there could be no precise assessment or prediction because effects could be so variable depending on the conditions of an explosion.

He concluded by stating that even with the horrors of possible atomic warfare in mind he believed that the ultimate consequences of the development of atomic energy would be vastly to the benefit of mankind. It was essential to view the subject in perspective, without political bias and without undue alarm.

Recent Advances in Parasiticides

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THE word "parasiticide" could be considered to include any chemicals used to kill parasites, and might cover a very wide range. In this short paper I propose to deal chiefly with developments in the control of the external parasites of domestic animals—lice, fleas, flies, blowflies, ticks, mange mites, etc. I shall also mention some recent advances in the control of helminths.

I had the privilege of addressing this Congress three years ago on behalf of my colleagues (Downing, Harbour & Stones, 1952). Our subject then was "Modern Insecticides and Ectoparasite Control." It is significant of the pace of modern development in chemical research that there is already something new to say on this subject.

The Older Insecticides

The modern surge of development really began with the discovery of the insecticidal properties of DDT and BHC, but before we pass to these synthetic organic insecticides we might just review briefly the present day uses of the older insecticides.

Rotenone is still used to some extent for the control of keds on sheep, and it is still frequently used for the treatment of small domestic animals for the control of fleas and lice. This natural insecticide is also in general use for the treatment of warble-infested cattle. Up to the present time no more effective substitute has been found for this purpose, though Smith & Richards (1954) have shown that certain organic-phosphorus insecticides are as effective as derris when applied as washes of concentrations of 0.5 to 1.0 per cent, while Roth & Eddy (1955) have also found phosphorus insecticides of value.

Pyrethrins, generally speaking, are too expensive and not sufficiently stable for use on animals, but in combination with a synergist, piperonyl butoxide, may be useful for the control of biting flies on cattle (Moore, Dove & Dickinson, 1954).

The same combination has been used in a low-pressure aerosol by Brander & Thomas (1954) for the control of red mite, northern mite, and lice, more particularly in poultry kept in batteries. This, I think, is a very useful advance. These parasites can be very troublesome, and this new method of control is simple, effective, and not too expensive.

Of the other older types of insecticides arsenic is still very widely used for the control of cattle tick. Its use for this purpose may have some disadvantages when compared with the modern synthetic insecticides, but it must not be forgotten that it was with arsenic that the United States authorities cleared the Southern States of the Texas Fever cattle tick.

Modern Synthetic Insecticides

Since the war-time development of DDT and BHC there has been development of a large assortment of synthetic insecticides, and new ones are frequently appearing. There is, first of all, a group of insecticides more or less closely related to DDT, of which methoxychlor is an example. Then there is a series of other chlorinated compounds of which the most important are BHC, toxaphene, chlordane, dieldrin and aldrin. Then comes a series of organo-phosphorus insecticides, including the more toxic ones like parathion, TEPP, and HETP, those of rather lower mammalian toxicity like diazinon, and still others of very low mammalian toxicity like malathion.

Most of the organo-phosphorus compounds have been developed for use on crops where their general properties of high insect toxicity and low stability are particularly useful. They are, however, coming into use in many areas for the control of fly populations which have become resistant to the chlorinated insecticides. McGirr & Papworth (1953) remarked that the organo-phosphorus compounds are "beyond doubt the most dangerous group of compounds used in agriculture to date," but in their paper these authors mentioned the possible evolution of compounds of this series which would be toxic to insects but harmless to mammals.

A great deal of attention is being paid to-day to the possible use of organo-phosphorus insecticides for animal treatment, and a number of papers have appeared dealing with the possibilities for control of various parasites. We must, however, proceed cautiously with this type of insecticide until we are quite sure about the possible toxic hazards, especially with repeated treatments.

Let us now look at some of the more important ectoparasites of animals, and see what advances have been made in their control.

Sheep Blowfly

At the time of the 1952 British Veterinary Association Congress the insecticide in general use in this country for control of blowfly in sheep was DDT Its activity was chiefly against the adult fly. In our paper to that Congress we mentioned the larvicidal action of dieldrin, and that insecticide is now already tending to replace DDT for blowfly control.

Dieldrin has been found to possess outstanding larvicidal properties, and to be remarkably persistent in fleece. Stones, Wood & Hart (1954) showed that this insecticide, applied by dipping at a concentration of 0.05 per cent. provided complete protection against body strike for 12 to 16 weeks, and against crutch

strike for 8 to 10 weeks. Somewhat similar results have been reported in Australia by Graham (1954), and there is no doubt that dieldrin has come to stay as a weapon against blowfly.

Du Toit & Fiedler (1953) have drawn attention to the property of diffusion shown by dieldrin and some other insecticides. This property permits their penetration from previously treated wool on sheep into the constantly expanding zone of growing wool. Compounds of the DDT group did not diffuse along the wool-fibres.

The very great larvicidal activity of dieldrin, coupled with this property of diffusion along the wool-fibres has made possible the achievement of a useful degree of blowfly control following the application of a light spray deposit on to the fleece of sheep.

This is an important advance because it has made practicable the development of mobile spray-races which can be set up at any convenient place on the farm, and allow the treatment of large numbers of sheep at low cost, and in the minimum time with the minimum of handling. DDT, BHC and aldrin do not give the same successful results as dieldrin does in this type of spray-race.

Mange and Scab

The sarcoptic and psoroptic mange mites are very susceptible to BHC, and this insecticide has been successfully used for the control of sheep scab, and of sarcoptic mange in cattle, pigs and dogs.

In the United Kingdom there has been no reported outbreak of sheep scab for the past three years, and in very many overseas countries scab has been reduced to a low level and is not now a problem.

Keds and Lice

The widespread use of dips containing DDT or BHC led to such a diminution in populations of keds and lice that two or three years ago it was difficult to find these parasites anywhere. Recently, however, we have seen heavy infestations of body lice (*Damalinia ovis*), and there is little doubt that this backward trend has been due to the disappearance of scab, and to the consequent cessation on many farms of any precautionary dippings.

Sheep Tick

There have been no recent advances in the control of *Ixodes ricinus*. In our experience BHC is still the best of the insecticides for this parasite, and it is quite widely used at a concentration of 0.06 per cent. gamma BHC applied as a dip to give a useful degree of control (Jolly, Stones, Page & Brander, 1953).

Cattle Tick

In recent years there have been considerable advances in control measures against the various cattle ticks. Of the insecticides available BHC, DDT and toxaphene have been widely used, while arsenic is still used on a very large scale.

For the control of the three-host ticks, *Amblyomma* spp. and *Rhipicephalus* spp., BHC is efficient, but toxaphene has recently been giving excellent control. It is used regularly at concentrations of 0.25 per cent. to 0.55 per cent., and when properly formulated and carefully used is not at all hazardous for the cattle treated with it.

One of the more important recent applications of toxaphene has been in East Africa, where cattle moved on the hoof from up-country areas had to pass through East Coast Fever infected areas on their way to the coast. Since the advent of toxaphene dips it has become possible to protect cattle *en route* through danger areas, and to deal with any ticks picked up before they have any opportunity of transmitting the disease. This is because toxaphene will kill every female brown tick (*Rhipicephalus appendiculatus*) before it succeeds in feeding. Prevention of engorgement of the tick is highly significant, since it is known that transmission of the East Coast Fever parasite, *Theileria parva*, does not take place until the tick has been feeding for at least 60 hours.

This advance is of outstanding importance because it makes possible the movement of stock through infected areas in which, because of water shortage, or for other reasons, it is not possible to establish regular dipping stations along the stock routes. Trypanosomiasis is often a hazard also, and this disease can now be tackled with such drugs as "Antrycide" and ethidium bromide. With these two advances governments will be able to develop schemes for the regular reduction of stock in over-stocked areas, and ensure better and more regular supplies of better quality stock for the meat plants. This then may be a notable contribution to the economic development of East Africa.

Development of Resistance

We have never come across any authentic case of a population of two- or three-host ticks having become resistant to any insecticide. The same cannot be said of the one-host ticks of the genus *Boophilus*. The development of insecticide-resistant strains of this parasite is a problem that has caused trouble for some years, and it can be a serious threat to the success of expensive eradication schemes. There are, in South Africa, populations of *Palpoboophilus decoloratus*, which are resistant to arsenic, BHC, and to some extent to toxaphene. At the moment these ticks can be satisfactorily controlled only with DDT, and if DDT-resistant populations arise control may become very difficult. In Australia there are isolated pockets of ticks resistant to BHC, and the appearance of a DDT-resistant strain has also been suspected, while in many other parts of the world BHC-resistant strains have appeared.

Toxaphene-resistance has not, so far, been troublesome, except in parts of Brazil, and it has been found in these areas that DDT will control the toxaphene-resistant tick very well.

All this means that efforts must be made to find new insecticides with which we can tackle the resistant populations. Some attention has been given

to organic-phosphorus insecticides since Legg (1950) demonstrated the promising effect of parathion on *B. microplus* in dilutions of 1 in 10,000 and 1 in 20,000. In Southern Brazil parathion has been used a good deal, but many accidents have occurred.

More work is needed in this field, and there is much more involved than just the killing power against the parasite. Residual activity, effect on oviposition, toxicity for the host animal, and stability of the insecticides are all factors which have to be studied.

Methods of Application

I have already referred to the use of sheep spray-races giving light surface sprays of dieldrin for the control of blowfly. There have also been important developments in mechanical spray-races for the application of insecticides to cattle. In East and South Africa the new spray-races are beginning to be used on a considerable scale. They are quite different from the spray-races mentioned in connection with sheep. They provide a large volume (some 180 gallons per minute) of insecticide wash at a pressure of about 20 lb. p.s.i. applied through banks of nozzles placed at suitable points along the race.

The cattle walk through a dense drenching spray, and are thoroughly wetted all over the body. The wash dripping from them is returned to the sump and pumped round again.

Spray-races of this type provide good biological control of ticks when used with suitable insecticide formulations. They have some advantages over dipping baths. The cost of the equipment and its installation is lower; the capital cost of charging the sump with insecticidal wash is low; fresh wash can be used for each day's spraying, and contaminated residues are small and easily disposed of. Moreover, the use of spray-races makes it possible to alternate insecticides, and to use insecticides which would be unstable in the dipping bath. This may eventually be a factor of importance in helping to delay the development of resistant populations.

Systemic Use of Insecticides

During the past few years numerous papers have been published on the "systemic use" of insecticides by their administration by the oral or subcutaneous routes. Earlier work by Wilson (1948) had shown that feeding BHC to cattle gave a worthwhile kill of ticks and tsetse fly feeding on them, but the dosage he had to use was too near the toxic level for the method to find practical application with this insecticide.

Recently McGregor, Radcliff & Bushland (1954) tested a variety of organic phosphorus insecticides in 5 per cent. solution in peanut oil injected subcutaneously in warble-infested cattle. They found that all dosages of diazinon from 5 to 50 mg. per kg. killed all larvae present at the time of treatment, and all appearing for the next two weeks.

This new method of application is a very interesting one, but it will not find practical application until we can find the right insecticide.

Such an insecticide must be reasonably persistent in the animal's blood and tissue fluids, but must eventually be eliminated or destroyed, or converted into non-toxic substances. It must not be laid down in the body so that potentially toxic residues accumulate to the danger of either the animal or its consumer.

The chlorinated hydrocarbon insecticides dieldrin and lindane give a useful insecticidal action when applied in this way, but they are retained in body fat for long periods, and repeated treatments may lead to potentially dangerous residues. However, this is a very fascinating line of approach, and it is possible that considerable advances in the control of some of the more difficult parasites may eventually come from this method.

PART II—ANTHELMINTICS

In the field of anthelmintics there are relatively few discoveries which can be described as "recent advances".

The discovery of the activity of phenothiazine, the evaluation of sodium fluoride as an ascaricide for pigs, and the development of hexachlorethane for liver fluke control in cattle and sheep, have been, until recently, the chief milestones on the road of progress.

However, we have recently seen the publication of a number of papers dealing with the activity of various piperazine derivatives, and these new anthelmintics have provided a notable advance in the control of human threadworms, and of ascarids and some other roundworms in domestic animals.

One of the earlier piperazine compounds used was "Hetrazan" (1-diethylcarbamyl 4-methyl piperazine hydrochloride), a drug originally developed for the treatment of filariasis, but simpler substances have recently proved effective against ascarids, and some other roundworms in domestic animals.

Sloan, Kingsbury & Jolly (1954) demonstrated the anthelmintic activity of piperazine adipate for *Ascaris*, redworm, and oxyurid infections in horses; for ascarids and nodular worm in pigs; for ascarids in dogs and cats, and for *Ascaridia* infections in poultry.

Further work with this drug has been reported by Lee (1955), who demonstrated its efficiency against *Neoascaris vitulorum* in calves, while Poynter (1955) confirmed its activity against *Ascaris equorum* and small strongyles of horses. This new anthelmintic has a very wide margin of safety, and can be given in both wet and dry food.

Another piperazine compound which has attracted attention is the stable compound of piperazine and carbon bisulphide which has been described by Leiper (1954), who confirmed its efficacy against *Ascaris* and nodular worm infections in pigs.

Yet another new anthelmintic has appeared within recent months. Burch & Blair (1955) have described the use of a powder containing 1.5 per cent. of cadmium oxide used at the rate of 1 lb. of the powder to 100 lb. of feed for the treatment of ascariasis in swine. Though the new drug can be conveniently

fed in wet or dry mash it does not seem to have such a wide margin of safety as the piperazine compounds.

In the field of application of anthelmintics there has been considerable attention paid to the development of automatic drenching guns. To tackle the problem of wool-staining due to phenothiazine, Australian manufacturers have devised a drenching gun with a plastic tube which passes through a protecting metal sleeve and goes down the oesophagus. The gun is efficient, and dosing can be rapidly carried out with no risk of wool-staining, a point of considerable importance when dosing fine quality wool breeds like Merinos.

Conclusions

In this paper I have put before you the more important advances in insecticides and anthelmintics, and in their methods of application. This is a field in which great progress is being made, and many pests which used to be quite troublesome have now been brought under control. There are, however, many problems. In the ectoparasite field we need an effective answer to the insecticide-resistant tick; we need more certain control of the warble fly, and we need better materials for the control of biting flies. In the anthelmintic field we need new drugs effective against trichostrongyle infections, and against *Nematodirus*, which has become so troublesome in some areas in recent years.

But on the whole the picture is one of steady progress, and we can be confident that these various problems will be solved in their turn.

Summary

1. The advent of modern synthetic insecticides has made possible the eradication of sheep scab and the effective control of sheep blowfly, keds, lice, sheep tick, various types of mange, and many other ectoparasites.

2. The most outstanding recent advance has been the development of dieldrin for sheep blowfly control. Dieldrin possesses outstanding larvicidal properties, and is remarkably persistent in fleece. With dieldrin at 0.05 per cent. applied as a dip long periods of protection are achieved against both body and crutch strike.

3. Unlike other insecticides tested dieldrin gives effective protection against sheep blowfly if applied as a light surface spray. This fact has made possible the development of run-through sheep spray-races.

4. Modern synthetic insecticides have made notable contributions to cattle tick control. Toxaphene is particularly outstanding, especially in the control of the vectors of East Coast Fever.

5. Some strains of *Boophilus* spp. resistant to various chlorinated insecticides have appeared, and research on the development of alternatives is in progress.

6. Mechanical spray-races developed in Africa are providing good biological control of ticks. Use of these races allows the economical use of fresh clean insecticide wash, and facilitates the alternation of insecticides.

7. Possibilities of the use of insecticides by oral or subcutaneous application are discussed.

8. In the field of anthelmintics the outstanding advance has been the establishment of the anthelmintic properties of piperazine adipate and some other piperazine compounds. They are effective, particularly against ascarids in all animals, nodular worm in pigs, and small strongyles in horses.

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THE SPEAKER'S INTRODUCTION

The Chairman (Dr. T. McNabb) said that before he asked Mr. Harbour to present his paper he wanted to say how pleased he was personally to see Mr. Harbour in Northern Ireland. Many of them would have happy recollections of Mr. Harbour's address at Harrogate, and they all looked forward to hearing what he had to say.

Mr. Harbour said: "Any lecturer giving a talk on recent advances must first of all decide where he is going to start, and in my case I am going to start at about three years ago. The field of parasiticides, insecticides, anthelmintics and what-have-you is a field which advances fairly rapidly because of the tremendous advances in organic synthetic chemistry. Because of that, it is necessary at frequent intervals to have a look round to see where we have got to. I should like to stress that when I use the word "we" I do not use it as the editorial "we" but I am referring to my colleagues—Downing, Brander, Stones, Jolly, Wood, Hart and Lee, and to some of my overseas colleagues, Ault, Purchase, Thorburn and Graham. All these men have been intimately concerned with the various developments which I shall be talking about.

"The development of insecticides in post-war years has been quite phenomenal, almost too fast for some of us. We all remember the great flourish with which D.D.T. hit the headlines, but since then there have been many other very much more efficient insecticides discovered. I want to say something about the relative toxicities of the different insecticides we use today."

In showing slides, Mr. Harbour commented:

"Toxicity figures are liable to be misleading because they are derived from a variety of experiments under different conditions. I thought that possibly the best way to give you a rough idea was to choose the oral LD 50 dose for small laboratory animals. If we start with D.D.T. we get

a figure of 250. Other drugs that have been developed since are toxaphene (60), dieldrin (85), aldrin (65), parathion (3), and malathion (>2000). We can compare these figures with those for older insecticides, for example pyrethrins (1500), nicotine (10) and arsenic (13).

"I want to underline what these insecticides have achieved. The most outstanding example, I suppose, relates to the control of sheep scab. These figures show the decline in numbers of outbreaks of sheep scab in the U.K. from 1947, when B.H.C. was first introduced, until the present day:—

1947	— 103	outbreaks
1948	— 69	"
1949	— 46	"
1950	— 26	"
1951	— 16	"
1952	— 1	
1953	— Nil	"
1954	— Nil	"

All over the world sheep scab, which used to be a major scourge of sheep, is now a disease of minor importance. Manges have been fairly well controlled, and if B.H.C. had not been discovered we should have been able to achieve very much the same sort of result with other insecticides. The other parasites and ectoparasites—lice and keds—are quite easily controlled by most of the modern synthetic insecticides. Different ones can be used to give good results, though some are better than others, but I shall not bore you with detail.

"The sheep blowfly is one of the most important pests in limiting sheep husbandry. One of the most unpopular features of shepherding in this country and, indeed, in other parts of the world where maggot fly exists, has been the need for examining sheep at short intervals and dressing those that require it. In Australia these pests cause enormous damage to wool and sheep, and what we have wanted all the time has been the insecticide that would give the longest possible protection. The outstanding recent advance in this field has been the discovery of the activity of dieldrin. It is extraordinarily persistent on fleece.

"A friend of mine from Australia told me about a year ago he was asked by a local wool expert if he could get him some samples of wool cut from sheep which had been treated with dieldrin. He did so—they had been dipped five or six months before—and they were tested as regards activity against moth and they were mothproof. Dieldrin sticks. It stays in the fibre and does its job. More than that, it seems to have the curious faculty of going down the wool fibre as it grows so that it looks after the sheep blowfly and maggot as they hatch from the eggs. Dieldrin has revolutionised blowfly control in England, South Africa, New Zealand and Australia, and it is going to mean an enormous saving in wool and time. It is perfectly safe to use at the concentrations that have been regarded as necessary.

"One development has been that of the portable spray apparatus which gives merely a light spray to the sheep. Some years ago we felt it would be a good idea to have available a spraying apparatus which the farmer could use in his fields. Dipping is always an unpopular business. We tried various insecticides we then had available, applying a light spray to the back of the sheep, and the results were poor. We decided to abandon the idea of spraying against blowfly. Then came dieldrin and we tried spraying again, and to our surprise we found we got as good results, or nearly so, as by dipping with the same insecticide. That led to a new type of portable spray apparatus, and I would emphasise that this new development has become possible as a method only because of the pronounced efficiency of dieldrin."

Mr. Harbour then showed a number of slides demonstrating the principal features of the new type of spray apparatus.

He continued: "I should like to mention another type of spray apparatus which is used for the control of ticks on cattle. Although modern insecticides are remarkably efficient against the cattle tick—one of the major scourges in many big stock-raising countries—there have been snags. One concerned B.H.C., which in a cattle dip bath would show signs of degeneration after a time. We have found that this degeneration is due to the activity of bacteria. A chemical can now be added to prevent it.

"Another snag is the development of resistance to insecticides. That is very important, because at the moment we are only one jump ahead of the resistant *Boophilus* tick. It was resistant to arsenic in many areas, and we have also seen the development of resistance to B.H.C., and in some cases to Toxaphene. In those areas where this resistance has developed we have to use D.D.T., to which the tick has not developed much resistance. There is need for a method of applying insecticide to cattle in which the wash is always fresh and by which a change can be made conveniently from one insecticide to another without 10,000 gallons of rather expensive material having to be emptied out of the tank.

"This has led to the development of cattle spray races. The cattle are walked through a corridor and they pass through hoops which carry nozzles, and the insecticide is pumped from a sump. Everything that falls from the animals is circulated again. At the end of the day there may be 40 or 50 gallons at the bottom of the sump, and that is thrown away. This method gives remarkably good coverage and just as good biological results as does dipping. It is becoming a very popular and convenient method of cattle tick control.

"There are other new methods of application concerning chickens. Mr. Brander was consulted some time ago about a number of infestations of red mite and other parasites of hens, particularly in batteries. He thought he would try an aeresol for treatment and he found it remarkably effective.

"In my introduction I have purposely stressed the really important things—blowfly, cattle tick, the development of resistance and the comparatively low toxicity of some insecticides, and I have left to the end what I know will be a very important subject, that of anthelmintics. I do not propose to say much about them, but just to mention that the outstanding development within the past three years has been the development of piperazine compounds. I am deliberately going to avoid saying anything about these because I know Mr. Griffiths is going to follow me and his interests lie particularly in that field."

The Opener

The Chairman then called upon Mr. Griffiths to open the discussion.

Mr. Griffiths said: "I should first like to say how grateful I am for the opportunity of opening a discussion on the interesting paper we have just heard. At past Congresses, and elsewhere, we have become accustomed to being brought up to date by Mr. Harbour on insecticidal research and practice. Today he has extended his field to include some of the more notable advances in anthelmintic development.

"In congratulating the essayist I should like to say how much I appreciate his contributions. The momentum of parasiticidal research has quickened so considerably in the past decade that it is difficult for those outside the specialist fields to keep pace with modern developments. I am sure that practitioners, with their multifarious interests and responsibilities, must welcome such concise reviews as the one that has been presented here this morning.

"I propose to consider anthelmintics first. In the anthelmintic field, Mr. Harbour has told us that although some new drugs have appeared there are relatively few discoveries which can be classed as "recent advances." In certain respects it is perhaps fortunate that speedy advances have not been made, for with rapid development in any chemotherapeutic field there is always a tendency to pass from one drug to the next without fully developing either; this appears to be the case with some of the antibiotics. Because progress has been slower with anthelmintics it has been possible to examine carefully the uses and limitations of those which have appeared in recent years. As a result we have been able to evaluate such drugs as phenothiazine and sodium fluoride. I do not mean to imply that we have found the sovereign remedies for all the helminthiases. Gross deficiencies exist. But chemotherapeutic progress is not measured in terms of new drugs alone; it is equally important to explore ways and means of applying the available preparations to the best advantage.

"This is illustrated in the case of phenothiazine where the development of continuous low-level administration as an adjunct to the control of some of the important strongyloid nematode infections of livestock provides a good example of the growth of a new concept in anthelmintic usage; a

concept which has arisen as a result of exploitation of the actions of the drug. In this connection the history of low-level administration is of interest. From the outset the employment of phenothiazine for therapeutic purposes entailed, and still entails, its use in full dozes, but in the early days of its evalution against trichostrongylid worms it was noticed by Shorb and Haberman (1940), working with sheep, and by Taylor and Sanderson (1940), working with goats, that although small sub-therapeutic doses had no immediate lethal effect on susceptible adult worms, the eggs that were excreted in the faeces failed to develop further. Similar findings were recorded later when horses infected with strongylid worms were given small doses of phenothiazine. Moreover, against susceptible nematodes in horses, in particular, small doses of the drug were found to have an extraordinary temporary sterilizing effect on female worms so that the egg output was markedly reduced. Following these early observations, a new approach to prophylaxis soon became apparent, for it became clear that if low-level administration could be made a continuous daily routine, without toxic effects, then a very marked reduction in pasture contamination could be effected. In this way young susceptible animals grazing along with older stock could be protected against serious infection. Practical methods of applying these principles have been worked out by numerous investigators, especially in America, but British workers, particularly Harbour and his colleagues (Harbour *et al.*, 1946). and Gibson (1949, 1950), have also been among the pioneers.

"In horses, largely as a result of the work of Todd (1952), it has been proved that the administration of phenothiazine to mares at grass as a low-level regimen proves a valuable means of protecting the foals against equine strongylidosis. In ruminants, phenothiazine/salt mixtures for the control of trichostrongylids in sheep in particular, and to a lesser extent in cattle, are in widespread use in countries where the ruminants' salt requirements are sufficiently high to ensure an adequate low-level daily intake of the drug. Unfortunately, in Britain, the additional salt requirements of our sheep are too low to ensure the ingestion of adequate amounts of anthelmintic and the method has not found favour here. On the other hand, a modified approach described by Leiper (1951) has potentialities for low-ground sheep in this country. Leiper showed that when ewes were dosed with a full therapeutic dose of phenothiazine ten days before lambing, and were thereafter given 1-1½ grammes of the drug daily in a concentrate ration for 9 weeks, the "spring rise" in the egg output of the ewes was prevented, pasture contamination was thereby reduced, and the lambs from the treated ewes gained weight more rapidly than those from untreated ewes in a control group on an adjacent pasture.

"Low-level methods are also applicable to birds. In pheasants, for example, where *Syngamus trachea* infection is still a problem, Clapham (1950) has shown that the incorporation of phenothiazine at a four per cent. level in the mash, as a continuous medication, effectively controls the gapeworm; in this case, by destroying ingested third stage larvae. Unlike low-level methods in mammals, however, this regimen in birds retards growth rate, but a small pheasant is better than no bird at all.

"So much for recent advances in the application of phenothiazine, let us now examine the most important new anthelmintic development to which Mr. Harbour has referred, the discovery of the value of piperazine and certain of its derivatives. Undoubtedly these have a very definite place in veterinary therapeutics. As ascarifuges, they fulfil the requirements of a good anthelmintic. They have a high degree of efficiency, removing nearly 100 per cent. of both mature and immature worms from the gut. They have a wide safety margin and can be given in wet or dry food. They are effective not only against ascarids, but also against certain other helminths in a wide range of mammals and birds. I do not intend to discuss all the uses of these compounds. Mr. Harbour has already given the indications. But I would like to mention a few points in connection with the use of piperazine compounds in pigs and horses.

"There is no doubt that for pigs on a wet feeding system, where sodium fluoride is contra-indicated, piperazine adipate, piperazine citrate, and the stable compound of piperazine and carbon disulphide provide very useful, safe anthelmintics against *Ascaris lumbricoides*; indeed they are the drugs of choice. For pigs on a dry feeding system, however, sodium fluoride carefully administered is equally effective. It is reasonably safe and, being relatively cheap, it is more economical to use. In such cases, therefore, there is little advantage to be gained by employing the more expensive piperazine preparations.

"In horses, there have been several reports on the value of piperazine adipate, and the recent critical tests described by Downing *et el.* (1955, are most encouraging. These authors suggest that the pre-eminent properties of piperazine adipate against adult and immature ascarids in the gut of horses, together with the low toxicity of the drug, afford, for the first time, an opportunity of eradicating *Parascaris equorum* from breeding studs. They state that the dosing of stock every seven or eight weeks, together with appropriate hygenic measures, could possibly put this very desirable objective within the reach of careful stud-managers. If this claim can be substantiated in practice another great advance will have been made.

"The activity of piperazine adipate in equidae is, however, not restricted to ascarids; the drug is also highly efficient against some of the small strongyles, nearly 100 per cent. *Trichonema* spp. being removed by a therapeutic dose. Against large strongyles (*Strongylus* spp.), however, its efficiency appears to be low. It is worthy of note that in its effects on these large and small strongyles its efficiency is essentially similar to that of phenothiazine, but the piperazine compounds have the advantage that they are safer than phenothiazine which exceptionally causes poisoning in animals having an idiosyncrasy to the drug. The low efficiency of piperazine adipate against *Strongylus* spp. is disappointing. As far as is known, there is no effective drug against these helminths, although Miller (1953) suggested that glycarsamide may have a higher therapeutic value than most agents. I do not know of any recent work on glycarsamide, but it would be most helpful to hear the comments of those who have had experience of it.

"There is one final point concerning piperazine adipate that I would like to make. I refer to its use in oxyuriasis, that troublesome condition of horses so difficult to control because of the lack of an efficient anthelmintic and the difficulty of preventing reinfestation. When the piperazine compounds were first examined it was hoped that these would solve the anthelmintic problem, but from a limited number of reports this does not appear to be the case. Sumner (1955, personal communication) has reported than in three infected horses, despite as many as three treatments with full therapeutic doses at approximately six-week intervals, the worm burden was not completely eliminated and the horses continued to show clinical signs. It must be admitted that the drug at a dose rate of 10 grammes per 100 lbs. bodyweight removes a high percentage of adult worms, but it is inefficient against immature forms. It follows therefore that more than one treatment is necessary in most cases, and between treatments an appropriate time interval must elapse so that the immature nematodes may reach the adult stage in which they are susceptible to the drug. Herein lies the difficulty. Unless the worms which mature in the interval between treatments can be removed before they oviposit, breakdowns will inevitably occur. Once eggs have been laid it is extremely difficult to prevent reinfestation despite rigid hygienic measures. It is my opinion that successful treatment of oxyuriasis requires a drug which will remove 100 per cent. of both immature and adult *Oxyuris* by a single, or close-interval, treatment. Piperazine adipate does not fulfil these requirements.

"Before I pass on to the insecticides, there is one topic which I should like to raise in the hope that somebody might enlarge upon it in the forthcoming discussion. I refer to the toxicity of hexachlorethane for cattle. Mr. Harbour has referred to the development of hexachlorethane as a milestone on the road of progress. Undoubtedly this preparation is of great value, but I am frankly disturbed by recent reports of poisoning in cattle in the border counties of Wales, the North of England and certain districts of Northern Ireland. In a letter to THE VETERINARY RECORD, published this year, Bywater estimated a death rate of at least 12 per 1,000. I am sure we should all like to hear Mr. Harbour's views on this matter.

"Now let us examine the arthropods. Mr. Harbour has given a most encouraging report on insecticidal development and he has outlined the results which have been achieved in the control of ectoparasites over the past few years following the introduction of the synthetic residual insecticides. Control of arthropods may be absolute or relative. That is to say in certain cases complete eradication is possible; in others only a reduction of populations to low levels can be effected. Sometimes such a reduction is all that is required or even desirable. The part that insecticides play in achieving these ends depends not only on the efficiency of the preparation available, but also on the ecological relationship between the parasite and the host.

"In the case of permanent ectoparasites, the chances of eradication by the use of insecticides alone are good. Mange mites, for example, fall in this category, and it is most gratifying to learn that following the widespread use of the outstanding acaricide, BHC, sheep scab has probably been eradicated from this country. It would be unfair to give all the credit to BHC; the Animal Health Division, through the pursuit of a vigorous eradication policy, also deserves recognition for this notable achievement. In connection with other permanent ectoparasites Mr. Harbour has referred to the great reduction in ked and louse populations on sheep which took place, some two or three years ago, following the use of DDT and BHC dips. But it is disturbing to find a retrograde trend in the reappearance of heavy body louse infestations in some flocks. That this increase is probably due to the cessation on certain farms of precautionary dippings since the disappearance of scab points its own lesson.

"In the case of arthropods which spend only short periods on the host; and/or those which may have alternative hosts for their perpetuation; and those which have extensive habitats for the various stages which live off the host—I am referring to blowflies and ticks in particular—eradication by the use of insecticides alone is much more difficult, and often impossible. But chemical protection of the animal is extremely valuable, and we have heard today of outstanding developments in this field. Toxaphene is very valuable as a quick-killing acaricide against ticks on cattle in countries abroad. Moreover, it has a residual effect on the bovine hair which is superior to that of other agents available for tick control. Its use in East Africa, as outlined by Mr. Harbour, for the protection of cattle passing through East Coast Fever areas will undoubtedly be of great benefit to the livestock industry in parts of the African continent. In passing it is of interest that although toxaphene is active against several genera of exotic ticks, it is relatively ineffective against *Ixodes ricinus*, the important ixodid tick in this country. There are specific differences in the susceptibility of ticks to this and other chlorinated hydrocarbons which still await an explanation.

"On the home front, the outstanding advance is the introduction of dieldrin for the control of blowfly myiasis in sheep; and the adoption of the spray-race technique for its application will certainly prove to be a valuable labour-saving device. The greatly improved protection afforded by dieldrin is a notable step forward in the control of one of the most serious afflictions of sheep.

"Before leaving this important subject of insecticides, I wish to say a few words about measures against arthropods in general. Without any doubt, the highly efficient insecticides of today have made an enormous contribution to ectoparasite control; sometimes they are the only means of attacking an arthropod. But it is important to realise that they are not the panacea for all our ectoparasite problems and in many cases there are other methods, such as biological control, which must be fully explored. There is, however, a tendency today to neglect biological methods in favour of chemicals sometimes with unfortunate results.

"Moreover, we must guard against the indiscriminate use of the powerful insecticides which are being developed, lest we upset the balance of nature. Consider an example from the agricultural field where the effective use of an insecticide against a particular pest has unfortunately, on occasion, also wiped out certain arthropod parasites and predators of other pests which are not themselves susceptible to the chemical employed. Following the elimination of the beneficial creatures, which were exerting a biological control, those pests unaffected by the insecticide, and now free from their natural enemies, have been able to multiply enormously and have thus created fresh problems. For example, DDT very effectively controls the codling moth, an important pest of apples, but unfortunately at the same time it kills the predators of certain red spider mites that are themselves pests of apple trees. The mites, however, are not affected by the DDT at the concentrations employed, and with the disappearance of their natural predators the mite populations are able to build up tremendously. The mites then become a serious problem whereas previously they were of little or no importance. In this way, the fruitgrower may be trading one pest for another (Pickett, 1949). In the medical and veterinary fields, as far as ectoparasites of man and his stock are concerned, there is little or no evidence that the balance of nature has been upset in this way. Nevertheless, with the present-day tendency to use insecticides more and more widely, it might be wise to remember the possible far-reaching effects on arthropods in general which may result from the indiscriminate use of chemicals.

"We must be discerning in the measures we adopt against particular parasites. Let it be remembered that, along with insecticidal development, there is a pressing need for a more detailed knowledge of the biology of arthropods as a whole. When we are armed with that knowledge, we may be able to use our existing preparations—and newly-developed ones—more effectively, as rapiers rather than as bludgeons."

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The General Discussion

Mr. G. B. S. Heath (Penrith) said that he wished to begin his remarks by thanking Mr. Harbour and his colleagues for the work they had done. How often during the course of the summer would the use of dieldrin be needed to prevent strike in sheep? From what had been said it might be assumed that one dipping after shearing would be sufficient. What would Mr. Harbour say was the best larvicide to use on struck sheep in the present state of knowledge in this field?

In spraying sheep with dieldrin, would it be possible to use a fine mist spray for sheep in a pen?

Mr Heath confirmed what had been said by Mr. Griffiths about hexachlorethane. The animals kicked, and got up and lay down again about two hours after being dosed. In only one case had he seen death follow dosing. During the past winter he had confirmed very heavy infestation of body lice in sheep on three occasions, though he had not seen the conditions in the area before.

Mr. Niel Reid (F.A.O.) said that he wanted to add his congratulations to those of the former speaker. In Africa the tsetse fly was responsible for excluding the livestock industry from very considerable areas. In recent years there had been a lot of work done there with insecticides, particularly in spraying areas in Zululand in South Africa. In East Africa the Colonial Insecticide Unit, he understood, had been carrying on experimental work over the last three or four years in an effort to eradicate the tsetse fly from bush which was infested and areas where livestock could be be maintained. Had Mr. Harbour any recent information on that work?

Dr. E. L. Taylor (Weybridge) said that his contribution would be of the nature of a general comment on present work in parasiticides. Mr. Griffiths had referred to the

momentum of research in parasiticides. But in actual fact it was confined to one very small part of the field. The rapid change from one parasiticide to another had been mentioned, we were living in an age that seemed to belong to the chemists altogether. This group of scientific workers had found a facile way of making new substances and, aided by biologists, had developed rapid screening techniques which directed their work to the discovery of new insecticides, and so there was an embarrassingly large number of new substances about which we know very little from the parasiticidal point of view. We have all frequently heard the exclamation: "What, another new detergent!" and it seemed justifiable to exclaim: "What, another new insecticide!" If one read carefully through Mr. Harbour's very excellent account, one found that exisiting knowledge amounted to little more than that while "A" would kill "B" it would not kill "C," and substance "D" would kill "E" and "C" but it was dangerous if used in "G".

Then there was the matter of drug resistance which added to the difficulties. It was now known that if a certain substance was continually used then after a time certain insects would give rise to drug-resistant strains. We went on then to use another drug and hoped that by the time the insects were able to resist that new drug the chemists would have produced yet another substance which would enable them to keep one move ahead. The position seemed rather unsafe and he felt we could wish we had a more fundamental understanding. It was fairly safe when a new detergent was produced, it was easy to know the potentialities, but when a new insecticide came along they were faced with a lot of unknowns with regard to toxicity, persistence and stability the animal on which it could and which it could not be used with safety and the effect of drinking the animal's milk or eating its flesh.

They looked forward to the time when Mr. Harbour would be able to tell them something more about the way in which insecticides penetrate the insects and how they operated against the metabolism, as also about the way in which drug-resistance might be overcome. It seemed strange that the drug resistance occurred only in arthropods and in certain protozoa, it did not seem to occur among helminths or vertebrates.

Mr. James Reid (Edinburgh) said that it stated in the paper, under "Conclusions," that a more certain control of the warble fly was needed. The body of the paper suggested that work in that connection was probably going on to find something which would injure the "grub" at some stage during its migration from, or stay inside, an animal's body. At the present time they did not get whole-hearted or even half-hearted co-operation from the farming community with regard to the warble fly; and, even if Mr. Harbour and his colleagues discovered a substance which could be given to animals to deal with it, it was doubtful one wondered whether there would be better co-operation from livestock owners. Was there any progress to be reported on a substance that would have a deterrent effect on the fly itself and prevent it ovipositing on its natural host?

Mr. J. W. Macaulay said he wondered whether Mr. Harbour could confirm or rebut definitely a suggestion made in Kenya by farmers that there was considerable resistance to phenothiazine. Good results on nasal fly which was a very serious problem in sheep in Kenya were obtained by the use of dieldrin dissolved in olive oil and injected subcutaneously.

The Reply

Mr. Harbour, in reply, said that he felt he wanted to rush straight into battle with Dr. Taylor, but would refrain from that at the moment and firstly answer those points made by the other speakers. In opening he had intended to refer to the size of the dose when speaking of anthelmintics, particularly in regard to piperazine compounds. Very often phenothiazine did not give as good a result as it might because the dose was too small. Many commercial firms had been taken to task by Dr. Taylor and others for setting the dosage scale too low. When a new anthelmintic was established there were many things to consider. The three most important were the effect on the worm, the effect on the animal being dosed and the effect on the farmer's pocket. It was the combination of those three factors which sometimes caused the use of an anthelmintic to be less efficient than it might be. Piperazine compounds should be used in really adequate doses. One could in fact administer many times the anthelmintic dose and get away with it. Recently one farmer had told his veterinary surgeon that all his pigs appeared to be dying, though none did die. They had been dosed with piperazine adipate at sixteen times the therapeutic level.

Much had been said about the toxicity of hexachlorethane. They remembered the letter which Mr. Bywater had written about it in THE VETERINARY RECORD. The mortality rate was nothing like the rate suggested in that letter; it was very much lower. If it were of such a magnitude as suggested by Mr. Bywater, the material would have gone off the market long ago. There were unfortunate cases occasionally apparently suggesting some idiosyncracy, but the problem over the whole country, and in countries overseas such as Africa, was not as large as had been suggested.

Mr. Harbour said that he wished to make a sincere apology to the Animal Health Division if he had inadvertently suggested that the control of scab was entirely due to BHC. He had not meant to do that. In the paper he and his colleagues presented at Harrogate it was pointed out that the eradication of scab in Britain was mainly due to the efforts of the Animal Health Division. BHC was only a tool.

The effect of toxaphene on Ixodes was mentioned by Mr. Griffiths. *Ixodes* was the most difficult tick of all. Nothing else seemed to equal BHC against it and BHC was useful to only a certain extent. It enabled farmers to keep the number of ticks down to reasonable proportions.

The final point made by Mr. Griffiths with regard to the use of a rapier rather than a bludgeon fitted neatly with Dr. Taylor's remarks, but Mr. Harbour wanted to reserve the pleasure of replying to those remarks until just a little later.

As to the frequency of applying dieldrin for blowfly, in Britain protection could be expected from it for the complete season, provided that adequate concentrations were used and the job done properly.

The most effective insecticide for dressing struck sheep was BHC. Other insecticides such as DDT or dieldrin incorporated with BHC had the effect of giving protection against subsequent strike, but the best insecticide for killing the larvae quickly and bringing them out of the wound was BHC.

A handspray pump and spray would provide a quite useful method for using dieldrin provided the concentration was adequate, say 0.25 per cent.

Mention was made of heavy infestations of body lice on sheep. In many cases farmers had ceased to dip at all because they were not bothered by maggot fly. It was not very long before the louse came back again.

The tsetse fly was very important in Africa and provided a severe limitation to cattle raising. Mr. Harbour had no very recent information on its control, but he knew that a good deal of work on it was going on in the Sudan and East Africa. The use of insecticides from aircraft, insecticidal bombs, the spraying of foliage were methods which were used, while bait cattle were sprayed with insecticides so as to kill the tsetse that landed on them. An interesting development was that of giving insecticide to an animal by mouth and letting it become a trap for the tsetse. Its application on a big scale was however doubtful because of the hazards inherent in the laying down of insecticide deposits in animal tissues.

Quite a lot of work had been done to find an insecticidal repellant which would prevent the warble fly from depositing or to kill the larva before it went into the animal. It was doubtful whether such work would succeed until there was a successful way of breeding the warble fly. There was said to be some work done in Canada which resulted in the breeding of the warble fly in captivity and, if that were so, it opened up new possibilities.

Mr. Harbour said he had heard other reports of resistance to phenothiazine by sheep helminths, but did not think there was very much substance in them. Frequent tests of phenothiazine had not shown it to be less effective than it was thought to be originally.

Dr. Taylor had said there was an embarrassingly large number of insecticides about which they knew nothing. In

that event, Mr. Harbour could only say that he and his colleague and others had been studying nothing for a very long time. Before an advertisement appeared for a new insecticidal preparation, the preparation was tested out on many parasites. Its physical and chemical properties were studied and efforts were made to poison animals with it, every possible test being applied. The material was then tested in the field on a fairly large scale so that any snags arising could be investigated. When it was quite obvious that it was going to be alright it was then released generally.

One got the impression from what Dr. Taylor said that insecticide resistance in the veterinary field was a very serious problem. It was not. Drug resistance had occurred in only one species, or three sub-species of one particular parasite, *Boophilus*. That was a very important parasite in the Argentine, in Australia, Brazil and South and East Africa, but it was not the only one. There was no case of resistance to insecticides developed by any of the two-host or three-host ticks; nor apparently was there any case of resistant blowflies, keds or lice. They might develop, but they had had a good run and had not done so yet.

The *Boophilus* tick was in contact with the insecticide for a long time. It went through nearly all its life on the animal and it was, during that time, in contact with the insecticide more or less continuously before it fell off. The more susceptible were eliminated and the less susceptible remained to breed.

More fundamental understanding, as Dr. Taylor said, was necessary. It was being sought but the results were not easy to come by. A lot of work was proceeding on insecticides and their effects. It was not published because it had not produced results which could be discussed. It was to be hoped that the rapier would be developed when fundamental understanding was achieved, but in the meantime farmers expected them to use the bludgeons—which were very useful bludgeons from time to time.

The Chairman said he could tell by the applause it was the wish of the meeting that he should convey their very best appreciation and thanks to Mr. Harbour for his fine paper and for the excellent manner in which he replied to the discussion. They would also want to thank Mr. Griffiths for his stimulating opening, those who had taken part in the discussion, and the recording secretary.

Safe Anaesthesia

BY

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MODERN anaesthetic practice is designed to meet three essential demands. First, the patient should undergo surgery safely and with minimal discomfort. Secondly, the surgeon's work should be facilitated, and thirdly, the patient should return promptly to a normal physiological state. No single-known drug can satisfy all these demands. In the absence of a perfect anaesthetic agent the anaesthetist to-day employs a combination of drugs or methods, each of which is used to produce a specific desired effect; the end result has come to be termed "balanced anaesthesia." Narcosis, analgesia and relaxation are produced as dictated by the requirements of the operation and any necessary fluid or electrolyte replacement is performed as the operation progresses. It must be emphasised, however, that the successful achievement of the anaesthetic aims for many simple operations on fit subjects may be obtained without resort to polypharmacy. Every case must be assessed on its own merits and rule of thumb methods can have no place in modern anaesthesia. The condition of the patient, the limitations imposed by the available apparatus and agents, and the skill and experience of the anaesthetist must always be considered when deciding upon the anaesthetic technique to be used for any particular case.

The aim of this paper is to indicate how, in veterinary surgery, it is possible to utilise old-established techniques and recently introduced procedures to provide smooth, safe anaesthesia for the patient with optimal operating conditions for the surgeon.

It is convenient to discuss anaesthesia under various headings—premedication, light anaesthesia, relaxation, shock and replacement therapy and assisting the surgeon.

Premedication

Pre-anaesthetic medication is given to make anaesthesia safer and less distressing for the patient. It is also given to make induction of anaesthesia easier for the anaesthetist. Except for very simple procedures premedication should never be omitted. It aims at producing a state of reduced reflex activity of the central nervous system and a decreased flow of saliva and mucus in an animal which has been made less apprehensive and more docile. The degree of activity of the central nervous system at the time of induction of anaesthesia determines the amount of anaesthetic which has to be used subsequently.

The many agents used for pre-anaesthetic medication include atropine, hyoscine, morphine, pethidine and various barbiturate drugs, all of which have been in use for many years and whose pharmacology is well known. The unrealiable action of morphine and morphine-like drugs in horses and cattle is generally accepted (Brit. Vet. Codex 1953). In the dog, experience indicates that the commonly used dosage scale for morphine is grossly excessive. Schlotthauer (1949) and Arthur, Vaughan & Yeats (1953) have reported on the use of intravenous pentobarbitone sodium in the horse, but this is not always easily administered to a restive animal and may not be as effective as was at first believed.

Although there are indications that chlorpromazine, a recently introduced phenothiazine derivative, may prove to be a very useful agent for premedication in all species of animal it is as yet far too early to assess its real value.

Light Anaesthesia

All recognised anaesthetic agents are general depressants affecting the whole of the central nervous system including the centres responsible for cardiovascular stability. It is generally recognised that the safety of a patient is inversely proportional to the depth of anaesthesia employed, provided always that the depression of the nervous system is sufficient to ensure absence of undesirable reflex response to trauma. Safe, light narcotic depression of the nervous system can be provided most conveniently by thiopentone sodium, pentobarbitone sodium or chloral hydrate given intravenously in doses just sufficient to produce loss of consciousness. The animal is then maintained in the unconscious state either by small additional doses of the same agent, or, probably more safely, by gaseous and/or volatile agents. In this unconscious state absence of reflex response to noxious stimuli can be achieved by the use of specific analgesic agents. To provide the necessary analgesia various agents are available the choice of which depends on the species of patient and on the surgical requirements of the case. They include nitrous-oxide-oxygen mixtures (with or without trichlorethylene) by inhalation, intravenous pethidine, or local, regional or spinal nerve blocks. A deep generalised depression of the central nervous system is never produced by these means and the animal regains consciousness soon after the administration of the anaesthetic is discontinued.

Relaxation

The production of muscle relaxation in association with light anaesthesia presents no great difficulties. Either specific relaxant drugs such as curare or succinylcholine chloride, or regional or spinal nerve blocks can provide adequate relaxation for any operation. The currently inadequate knowledge concerning the action of the relaxant drugs in large animals constitutes a deterrent to the use of these agents in large animal practice and local analgesic techniques are commonly employed instead.

Dinsmore (1950), Jones (1950), Harris (1951), Pickett (1951), and Hall (1952) have recorded the use of curare-like drugs in veterinary anaesthesia, while Hall (1952a), Hall, Lehman & Silk (1953), and Stowe (1955) have reported on the use of depolarising agents in the dog and horse. Experience indicates that the curarising drugs have a similar safe action in cats, dogs, pigs and horses, but in ruminants their use appears to result in unexplained deaths. On the other hand the duration of the effects produced by depolarising agents varies with the species concerned.

There are two definite contra-indications to the use of the specific relaxant drugs in veterinary anaesthesia. For humane reasons these agents must never be given unless the animal is already unconscious from doses or concentrations of recognised anaesthetic agents which are known from previous experience to be capable of maintaining adequate anaesthesia for the whole of the expected duration of the neuromuscular block. Also a relaxant should never be administered unless facilities for immediate and sustained artificial respiration are available.

In farm animals, particularly in cattle, local analgesics are commonly used to produce local, regional or epidural nerve block. Relaxation is assured when sensory or motor nerve fibres are blocked since muscle tone depends on the presence of an intact reflex arc. Perhaps it is unfortunate that under general anaesthesia it is easier to produce muscle relaxation in dogs and cats by giving a relaxant drug than by performing a regional nerve block. It is undoubtedly safer to employ a regional or epidural nerve block than to use a specific relaxant drug.

Shock and Replacement Therapy

The prevention and treatment of shock and the replacement of fluid and electrolyte deficiencies in surgical patients are coming more and more within the sphere of activity of the anaesthetist. The fluid and electrolyte requirements of the patient are, of course, determined in consultation with the surgeon, but only the anaesthetist is in a position to institute intravenous therapy during the progress of an operation. Intravenous fluids are best given by drip infusion, and the setting up of a drip—even if it means actually cannulating a vein when ordinary venipuncture is impossible—may be a life-saving measure.

In veterinary practice the fluids generally available for intravenous replacement therapy include the plasma substitutes such as dextran solutions, 0.9 per cent. sodium chloride and 5.0 per cent. dextrose solutions. Dextran solutions are very useful for restoring the circulating blood volume, although there are indications that the infusion of large amounts of dextran solution can result in an increase in the bleeding time with haematoma formation at the operation site. The amount of any plasma volume expander such as dextran solution to be given to any particular case is, at the moment, determined by clinical experience alone. Much more research is needed to determine the average blood loss occurring during various operations. Such work would do much to indicate when and in what quantities plasma volume expanders are required.

Sodium chloride and glucose solutions are used for restoration of sodium and water balance. If the observations of Le Quesne (1953) in man are also true for animals and there are two separate phases of sodium and water retention post-operatively, there is the possibility of overloading if saline and glucose solutions are administered. The danger of overloading is increased in animal patients because of the great difficulty in recording such important data as the fluid intake and output. In view of the limited knowledge of the whole subject in animal patients, parenteral glucose and electrolyte solutions should be used with very great caution. While every effort should be made to replace abnormal losses, as in profuse vomiting or diarrhoea, it is probably safer in most cases to rely upon voluntary intake of fluids by mouth in the immediate post-operative period.

There is clinical and experimental evidence that the use of chlorpromazine or hexamethonium compounds prevents the onset of surgical shock in patients subjected to major surgery. It is postulated that by rendering the patient incapable of reacting to trauma by the usual method of peripheral vasoconstriction to maintain the blood pressure these compounds prevent the occurrence of capillary anoxia and increased permeability which characterise irreversible shock. Where shock is already established the administration of these compounds may prove fatal to the patient.

Assisting the surgeon

The anaesthetist must be prepared to be an active member of the surgical team and to facilitate the surgeon's work in every possible way. The anaesthetist must aim at providing the surgeon with an accessible relatively dry operative field with adequate relaxation where required.

Surgical haemorrhage can be minimised by a tourniquet when the operation is on a limb, but other methods must be utilised to lessen haemorrhage during operations on other regions of the body. A knowledge of physiology enables the anaesthetist to provide the best possible operating conditions. When carbon dioxide is allowed to accumulate in the patient, vasodilatation and an increase in blood pressure, particularly the systolic pressure, results in profuse surgical haemorrhage. The anaesthetist must ensure efficient carbon dioxide elimination principally by avoiding undue respiratory depression, but if this is inevitable, as when muscle relaxants are being used, respiration must be assisted by artificial means to ensure an adequate tidal exchange. Venous haemorrhage and capillary oozing may be minimised firstly by avoiding respiratory obstruction which is a cause of increased central venous pressure, and secondly by ensuring that where possible the operation site is raised above the general body level thus providing good venous drainage from the area. In certain carefully selected cases controlled hypotension techniques can render an operation site almost bloodless. Hypotensive methods while often very effective are certainly not without danger in themselves.

Discussion

The adoption of aseptic methods and the widespread use of antibiotics and chemotherapeutic agents has increased the scope of operative interference in veterinary surgery. Further advancement awaits the development of safe reliable anaesthetic procedures in all species, and each of the species of animal presents its own particular problems to the veterinary anaesthetist. It must be admitted that safe anaesthesia is not at the moment easily attained in some species.

Many veterinary surgeons are neither aware of the excellent operating conditions which can be provided by modern anaesthetic methods, nor have they had demonstrated to them the very satisfactory post-operative condition of animals after these "balanced" techniques have been used. The acquisition of some special ability and skill in the administration of anaesthetics by one member of the qualified staff of a practice would benefit both the surgeon and the patient. It must be emphasised that complicated anaesthetic machines are not essential for the administration of a balanced anaesthetic and simple satisfactory apparatus can often be improvised.

Safe anaesthesia is the result of the application of knowledge derived from the basic science of physiology to clinical surgical problems. However, since no technique or drug is safe in inexperienced hands a prospective anaesthetist must be prepared both to study physiology and to gain all possible experience in the practical use of anaesthetic agents and methods. Only when sound theoretical knowledge is allied to manual dexterity will it be found possible to assess new drugs and concepts and apply them safely to clinical problems.

Summary

Premedication is considered to be essential for all but very minor operative interferences. The combination of narcotics with analgesic and relaxant drugs to provide good operating conditions without gross depression of the central nervous system is discussed. The position with regard to the parenteral administration of fluids and electrolytes is regarded as being unsatisfactory. Some of the ways in which the surgeons' work can be facilitated are mentioned and it is emphasised that safety in anaesthesia depends on the experience, practical ability and theoretical knowledge of the anaesthetist.

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THE SPEAKER'S INTRODUCTION

The Chairman, Mr. D. Laird: "Gentlemen, we have a very important subject for discussion here and I will ask Mr. Hall to introduce his paper."

Mr. L. W. Hall (Cambridge) said: "First of all, I should like to take this opportunity to thank you for the honour you have bestowed upon me in inviting me to give a paper to the profession on the subject of anaesthesia. My remarks now will be very brief because I do not want to take up too much of the available time.

"As we all know, during recent years the pharmacologists have put many new and sometimes very potent drugs into the hands of the clinician. Some of these drugs have been used widely, if perhaps not always very wisely, and I feel that we should endeavour to derive full benefit from these drugs to the advantage of our patients. Here, as always, I think the welfare of our patients must be foremost in our minds, and since no anaesthetic of any nature can ever be completely safe from the point of view of the patient, the use of these new drugs must be approached, I think, with considerable caution. In fact, I believe that to venture into the field of modern anaesthesia, a sound knowledge of a basic science, such as physiology—using the term 'physiology' in its widest sense—is essential and this theoretical knowledge must be coupled to a degree of manual dexterity which makes the accurate insertion of a needle into a vein or a tube into the trachea a routine procedure as these are really only fundamental steps in the administration of an anaesthetic.

"Perhaps the emphasis in the paper is rather on the theoretical side so I will attempt to balance this by showing a film which indicates some of the more practical aspects of administering anaesthetics, namely, those procedures associated with endotracheal intubation in the various species of animal. I would like to emphasise that the film you are about to see has been made specifically for the purpose of teaching undergraduate veterinary students. Also, I must confess that it was our first attempt at producing a teaching film of any description, so I want to apologise in advance for any deficiencies in the subject matter or in the photography. Finally, I hope that this film will supplement the paper and that together they will give rise to much healthy criticism and discussion from all here to-day."

(The film "Endotracheal Intubation" was shown.)

The Opener

Dr. Spreull: "It gives me great pleasure to congratulate Mr. Hall on his most interesting and instructive contribution to our knowledge of veterinary anaesthesia. From his paper and from previous work published it is evident that we have with us to-day a young man of ability and enthusiasm who seems determined that our skill with anaesthesia should keep pace with progress in surgery. No one can deny that in the last decade we have made great strides with surgery. Few, however, can dispute that since Brook's work on spinal anaesthesia and Wright's introduction of the barbiturates, no great improvement in anaesthesia has been generally adopted in practice.

"Brook's work received little favour and was put to little use in the teaching colleges in Britain, probably due to the restrictions of the Animals (Anaesthetic) Act, 1919. Thanks, however, to the activity of the B.V.A., we are now free to take full advantage of his excellent work.

"The careful techniques so ably propounded by Professor Wright made the barbiturates first choice with the practitioner and this pride of place they still hold. Skill and knowledge acquired with practice gave further advantages, but to-day general anaesthesia is responsible for a death rate of at least 1 in 200—surely not a very great achievement when one considers that a very high percentage of our patients are excellent anaesthetic risks.

"In this paper presented by Mr. Hall, we obviously have the outcome of some years of careful and critical work. We have presented to us not only the general principles but much of the detail which we require to bring our skill in anaesthesia in line with progress in surgery. We have directions which should reduce anaesthetic risk to more reasonable proportions.

"It is my privilege to open this discussion and in doing so my directions are to express the practitioner's point of view. As all you practitioners know, a very important point is that, not only must the practitioner give the

anaesthetic but he must also be the surgeon. Complicated anaesthesia and anaesthetic techniques that require continuous attention have advantages which are vitally necessary in many procedures, but in the interests of economy these must be kept to a minimum. The veterinary surgeon in practice must endeavour to serve the best interests of as many patients as possible by simple anaesthetic procedure, preferably attended to before the operation. In this respect his purpose is well served by three methods; local anaesthesia, spinal injection and general anaesthesia with one of the barbiturates. By either of these three methods he gets the freedom he requires, both to be the anaesthetist and to be the surgeon. Local anaesthetics may be given by surface application, by infiltration, or by regional anaesthesia (field or nerve block). Spinal injection may be epidural or subdural. With general anaesthetics, and the barbiturates are no exception, an anaesthesic death rate of at least 1 in 200 can be expected. That is the figure Mr. Hall has given and I think few of us can aspire to as good an average. My records show, however, that with local or spinal anaesthetics we can reduce this death rate to about 1 in 2,000.

It is therefore very much in the interests of our patients and ourselves to use local anaesthetics or spinal anaesthetics whenever convenient. They have the advantage of being efficient, easily controlled and easily administered. They have few side effects, they are inexpensive, restraint is easy, they require little or no after-care, the patient makes a very rapid recovery and, above all, they are relatively non-toxic. The safety factor or therapeutic coefficient is high. With spinal anaesthesia or epidural anaesthesia, the coefficient is given as four. In other words the lethal dose is four times higher than the anaesthetic dose. We endeavour in our practice to do as many operations as possible under local or spinal nerve block anaesthesia. It is the normal choice for the following operations: excision of anal sacs, anal and perianal tumours and fistulae, inguinal hernias, urethrotomies, castrations, mammary tumours, reduction of fractures and dislocations of the hind limb, inter-digital cysts, caesarean sections, some toxic hysterectomies and laparotomies, some amputations, some teeth extractions, abdominal palpation for foreign bodies, calculi, and manipulations in whelping.

"More recently anaesthesia in the fore limb by brachial plexus block has been attended with success. Anaesthesia for the reduction of simple fractures has been effected by injecting procaine into the side of the haematoma, a quite simple procedure though it is usually necessary to perform it under X-ray.

"My experience is largely limited to the use of procaine as a local anaesthetic and to the hyperbaric solutions of procaine and nupercaine for spinal nerve blocks. In my opinion, premedication is required only with a fractious animal. It is unnecessary in the great majority of cases and it is contra-indicated in all cases when depression or shock is severe. The premedicants I favour are morphia or diethylthiambutene hydrochloride.

"I am most interested to have Mr. Hall's opinion on the worth of the newer local anaesthetics, the value of hyaluronides, the premedications, if any, which he favours for spinal nerve block, and the value of ephedrine pressin or phedracin to control blood pressure, with spinal nerve block.

"The topographical limits of local or spinal anaesthesia or the advantage of an unconscious patient necessitate that many operations and manipulations are done under a general anaesthetic. As already stated, in our practice the barbiturates are favoured. Pentobarbital sodium is most commonly used, but it can be said with truth of them all that it is fatally easy to administer anaesthesia.

"The barbiturates are powerful respiratory and circulatory depressants; further, they have a very narrow margin of safety, only one-tenth. For example, if it takes 10 c.c. of pentobarbital sodium to anaesthetise an animal, 11 c.c. will probably kill it. We take the following precautions to minimise the dangers and limit fasting to 18 hours. (I find that if starving is prolonged our troubles increase.) Sometimes we may charge the liver by feeding glucose. We use a good syringe, a sharp needle, and have the animal well secured. Many difficulties are caused by the use of a blunt needle or an ill-fitting syringe. In all but the very largest breeds we dilute the anaesthetic with equal parts of water, making the injection slowly but continuously until the delirious stage is passed. That usually takes about a minute. The threshold of anaesthesia is approached with great caution by injecting at quarter-of-a-minute intervals until the digital reflex is very weak or absent. For this final stage the anaesthetic is still further diluted, one to eight with water.

"In cases of laryngeal spasm, snoring, respiratory embarrassment, in all short-nosed breeds, and for most operations on throat, nose and mouth, a McGill's endotracheal tube or a similar tube is used to provide a free airway. For operations on throat, nose and mouth we pack the pharynx with gauze in order to prevent the swallowing or inhaling of foreign material. Barbiturate patients require post-operative attention with particular care in maintaining warmth. We find a most convenient method of maintaining warmth is an infra-red ray lamp. The administration of glucose after a barbiturate anaesthetic has been given will cause the patient to pass into deeper anaesthesia. In the event of collapse, methylamphetamine hydrochloride and saline transfusions have proved most effective. Oxygen and artificial respiration are of some value if collapse is very protracted.

"Safety precautions notwithstanding, we consider that the barbiturates are contra-indicated if the patient suffers from severe cardiac or respiratory embarrassment, from advanced hepatic or renal dysfunction or from toxic or infective conditions. In the old and in the ill, in addition to routine general examination, the simple safety measure of a urine test for bile pigments and albumin will give some guidance to the efficiency of the liver and kidneys, as will a blood test for sedimentation rate provide valuable warning to toxic, infective or cancerous states.

"When the barbiturates are contra-indicated for general anaesthesia, skilled assistance is required for the continuous administration of volatile or gaseous anaesthetics. Such anaesthesia we find is no more dangerous than the barbiturates.

"Mechanical ventilation for chest surgery can simply and effectively be performed as follows: The patient is anaesthetised by pentobarbital sodium. A cylinder of air, oxygen, or a simple bellows keeps a rebreathing bag lightly inflated. The bag is connected with an adjustable escape valve to an endotracheal tube and with this tube in the trachea the pharynx is packed with gauze to seal off the lungs and permit inflation. Ventilation is then effected by interrupted pressure on the rebreathing bag and by suitable adjustment of the escape valve. The cost of such apparatus will not exceed £3. Cuffed tubes, flow meters, CO_2 absorbers and a variety of taps to introduce gases and anaesthetics give advantages but they are not essential. I do not use cuffed tubes now. I find great difficulty in getting the range of sizes that I require and by packing off the pharynx with gauze I get the same results. Muscular relaxants have gained little favour with us. The benefit that undoubtedly results from their use is offset by probable dangerous complications—interference with the swallowing reflex, paralysis of respiratory muscles, irritant local effects and the possibility that the patient may be paralysed and not anaesthetised. In this connection I should like to know if the cardiac pain reflex can be considered a reliable guide to the state of anaesthesia in a relaxed patient.

"These remarks of mine refer primarily to the dog, but to some extent to all animals. I hope that they have contributed something to the discussion on safe anaesthesia. Mr. Hall, in his paper and by his film, has given us a wealth of information which will greatly assist us in reducing the dangers of anaesthesia. It is most valuable information to the profession and a most important contribution to this congress.

The General Discussion

Mr. S. Jennings (Glasgow) congratulated Mr. Hall upon his excellent paper and said that he was glad Mr. Hall had devoted his remarks to what he considered to be the hardest part, namely, intubation. In the larger animals, particularly the horse, he found that the blind passing of the McGill's tube was easiest after premedication with

thiopentone. The McGill's tube was passed through the mouth, and the larynx was seized and threaded on to the tube rather than the tube pushed into the larynx. It went in quite easily and the pointed end of the tube could be felt moving up and down the tracheal rings quite readily.

Referring to the passing of the hand into the mouth of the bovine as depicted in the film, Mr. Jennings said that many of the bovines he had anaesthetised had been calves in which this procedure was impossible and therefore he had to depend on blind passing. Whatever anaesthesia he used, he liked to intubate because of the risk of regurgitation of rumenal fluid, and even if one was using a non-volatile anaesthetic one felt safer with regard to that risk.

The sheep was a little more difficult than the horse and bovine, but if the anaesthesia was light the animal coughed very readily and that cough was very useful for slipping in the tube at the vital moment.

Mr. Jennings wondered why Mr. Hall had not used thiopentone in the case of the sheep as cyclopropane was expensive and would all be wasted in premedications. He had used thiopentone in sheep and found it very satisfactory.

Dr. A. T. Philipson (Aberdeen) congratulated the author on his extremely interesting paper. He appreciated the value of intubation with ruminants for operations which took a long time and in which there was a risk of regurgitation, but with small ruminants many of the operations commonly used in experimental surgery, the time taken for anaesthesia are known. For these animals he had found the barbiturates a very safe anaesthetic. When performing a small, simple surgical operation it was easy to put a sheep down with an intravenous injection and it was perfectly safe. Respiration could be judged perfectly well. Anaesthesia could be obtained for 20 minutes by a single injection which for most clinical purposes was probably long enough. In a longer operation more had to be given and the dose decreased with time. The method of intubation for large operations obviously had very considerable advantages, but he asked Mr. Hall whether he thought those manipulations were necessary in operations of short duration.

Mr. W. J. Jordan (Wrexham) said he had tried a certain anaesthetic which had been on the market for quite a while and that he would like to bring it to the attention of the meeting because it was a very safe anaesthetic. It was brought to his attention by a specialist dealing with young children and was a mixture of one part vinyl ether to three parts ethyl ether. He had found it a good anaesthetic, particularly in cats, in that one attained a very rapid induction of anaesthesia without any premedication. He had also used it in dogs and found that the safety margin was so great that in some cases it had been quite impossible to destroy the animal with this anaesthetic. He used an oxygen apparatus as it was a volatile anaesthetic and he could put down the patient and continue the operation successfully alone and unaided. The oxygen flow meter was set at a predetermined level and the anaesthetic continued throughout the operation. He asked if the speakers had any experience of this anaesthetic and, if so, what they felt about it.

Mr. A. Thomson (Glasgow) said he would like to congratulate the speakers upon their excellent remarks. Perhaps he had not fully grasped what Dr. Spreull had said about the value of spinal anaesthesia and he wished to give a warning. Dr. Spreull had mentioned its efficiency in many abdominal interferences. Mr. Thomson believed that in hysterectomy and ovariotomy it was not an effective anaesthetic. It was effective as far as the cutting of skin and muscle was concerned but it was not effective otherwise and there was considerable distress occasioned when traction on the ovarian ligaments took place, which appeared to be evidenced by considerable pain in the chest region. He agreed with Dr. Spreull, that it was very good for caesarean section and fractures.

He suggested that an agent which might be considered for experimental or investigation purposes was pethidine hydrochloride. It was one of the fairly safe agents which had a resuscitating effect on shocked patients. Within the last year he had had the opportunity of trying it on a dog which had sustained shock and dislocation of an elbow in a motor accident and it was remarkable how the signs of shock were reversed and how easy it was to replace the dislocated elbow, good relaxation and analgesia having been produced.

However, he was far more interested in the remarks of Mr. Jordan on the use of a mixture of vinyl and ethyl ether as a volatile anaesthetic induced by an ordinary mask. No matter how skilled one was in the introduction of intravenous needles, he thought the average general practitioner would be attracted to a method as controllable in administration as was chloroform anaesthesia. Vinylethyl ether mixture seemed to offer some scope for the general practitioner in the safe induction of anaesthesia.

The Reply

Mr. Hall, in replying to the discussion, expressed his thanks to Dr. Spreull for the able way in which he had opened it and said he had put the case for the practising veterinary surgeon very well.

Mr. Hall held the belief that certain operative interferences in all animals to-day were outside the scope of the general practitioner. That was being forced upon them, and it was only in the larger centres with their equipment and facilities that these often extensive and major procedures could be undertaken. It was unfortunate, but the stage was being reached where veterinary surgeons had to realise that certain things could not be done in general practice and if at all possible they had to get the animals into well-equipped centres.

Dr. Spreull was the acknowledged expert on local and epidural techniques, having probably done more in this connection than any other man in the country, and he was very experienced in their use.

But any technique depended upon the man who was using it. No matter what technique or what agency was being used, it was only as safe as the person who was using it.

Mr. Hall's results with local and spinal techniques had not been 100 per cent. satisfactory, probably due to lack of experience and lack of skill in their administration, but they had a very great part to play in the administration of balanced anaesthesia.

Anaesthesia was split into three components: narcosis (or sleep), analgesia (or absence of pain sensation) and relaxation. Some operations required all three, some only one and some two. An X-ray examination on a restive animal only required sleep to keep it still. A minor operation on a dog might require relaxation to keep the animal still and analgesic. Major operations required a very high anaesthetic standard if the surgeon's work was not to be impeded and all three components had to be employed.

In using the epidural one was going to block the spinal nerves and there was going to be a fall in blood pressure due to the pooling of blood in the abdominal vessels. The magnitude of the fall in blood pressure depended upon how high one pushed the epidural. A low epidural did not have much effect upon blood pressure and therefore one did not have to worry a great deal about premedication. In a high epidural such as was commonly used in sheep for caesarean section, when one was going up to about T.4, the fall in blood pressure was often considerable and it was important to avoid using any agent which would lower blood pressure in premedication. Chlorpromazine, which he had used extensively for premedication, had the disadvantage that it would lower blood pressure and destroy the vasomotor mechanism or at least temporarily paralyse it. Anything which in itself would affect blood pressure or the vasomotor mechanism had to be avoided if the epidural block was going to be pushed very high.

He had thought the epidural block was pretty good and reliable but he had met cases where he was completely unable to get the epidural high enough for the operation. He had met other cases where the solution had apparently got high enough and where analgesia was fairly good but where one patch of the abdominal wall was still sensitive. He had no explanation to offer but he had seen it not only in domestic animals but also in man. He had seen a woman subjected to caesarean section under an epidural who had had very good analgesia except for an area just anterior to the pubis. He had met the same situation in two sheep where an area just in front of the pubis was not desensitised.

He had to cross swords with Dr. Spreull on the question of warmth post-operatively. Physiologically it seemed to be altogether wrong to warm a shocked animal and many of the medical profession regarded it as almost a criminal offence to warm a shocked patient. If one regarded shock as being a decrease in circulating blood volume, the body would attempt to compensate by peripheral constriction; in other words, it would attempt to shunt more blood to the vital areas such as the brain, liver and heart. If the animal was warmed it caused peripheral vasodilatation of the skin and muscle and the animal no longer had sufficient blood to fill the vascular bed and to supply the requirements of the brain and heart muscle. He had never got to the stage of putting an animal on ice as had been done with some humans, but he believed he had killed at least two shocked animals by the injudicious application of warmth.

Some of the vasodilator drugs, such as hexamethonium and chlorpromazine, tended to prevent the onset of irreversible shock. Presumably they stopped the body reacting with a compensatory constriction, the capillaries did not become anoxic and maintained their normal permeability. If one could prevent capillary anoxia by using vasodilatation drugs which prevented vasoconstriction, there seemed to be a much better tolerance to shocking procedures.

He confirmed Dr. Spreull's remark that glucose would prolong barbiturate intoxication.

With regard to analeptics, it was always wisest to keep out of trouble and not to stick in everything in the hope of doing something. The only analeptic which had produced results was "Coramine" which was used to stimulate respiration, perhaps after operation when respiration was depressed, possibly due to inadequate removal of CO_2.

Discussing chest anaesthesia, Mr. Hall agreed that one could do it with simple apparatus, but before long one would run into trouble. The problem was not only the supply of oxygen but it was also the removal of carbon dioxide. Unless one used a soda lime canister, or some sort of absorbent, one had to use a terrific flow rate to cope with the unexpired gases and it was uneconomical. In the dog a flow rate of about eight to sixteen litres a minute was needed. Therefore, it was essential to have a sodalime canister and to ensure that artificial ventilation was quite adequate. CO_2 only stimulated respiration in low concentrations when the respiratory centre was not anoxic. An anoxic respiratory centre would not respond and CO_2 itself could have a depressive action.

Dr. Spreull was worried as to whether animals under relaxants were in fact anaesthetised or just paralysed, and that problem had struck Mr. Hall very early on. He would certainly not use a relaxant if he was not quite sure in his own mind that the animal was unconscious and completely unaware of pain sensation. There were certain safeguards. It was known from experience that a certain dose of a certain thing, or a certain concentration of a certain gaseous anaesthetic would keep an animal unconscious for a given length of time in the absence of relaxants. If one used that dose or that concentration, the animal should be unconscious. Secondly, unless one gave a colossal dose of a curarising drug, the animal could still respond to painful stimuli by movement. In the dog there was a twitch of the facial muscles and sometimes a twitch of the limbs, and in the horse one found movement of the limbs, so, although it was said to be paralysed, it could still move in response to painful stimuli. Thirdly, there was the pulse rate. If the pulse kept rising for no apparent reason, such as excessive surgical haemorrhage, then the animal needed more narcotic and/or more analgesic. In abdominal operations which necessitated a relaxant which would depress the respiration, he much preferred to use full controlled respiration than to have an animal breathing inadequately on its own. One could soon tell if an animal was receiving pain stimuli by a feeling in the bag, the bag getting tighter as a result of a bronchial spasm, when one could not inflate the lung so easily. He was quite convinced that the animal remained anaesthetised throughout the whole period it was under a relaxant. The animal should breath with the ordinary respiratory pattern. There should not be the typical curarised respiration (which could be found in certain instances besides curarisation—although not very many) where there was inspiration with a pause before expiration. If this occurred one gave neostigmine to "knock out" the residual curarisation and achieved the normal anaesthetic respiratory pattern.

Mr. Hall emphasised that the film "Endotracheal Intubation," was not meant to show the only way of doing it. He would be the last person in the world to say that there was only one way of doing things. For any given operator, the method he knew was the best Dr. Spreull had hit the nail on the head when he said that if he had his appendix out he would rather be anaesthetised by an old practitioner who knew the method of dripping ether on a mask than by some bright "new" anaesthetist who shot in every drug under the sun knowing very little about the agents he was using.

In reply to Mr. Jennings, Mr. Hall said that in the case of calves he found it simpler, if one had not got a laryngoscope, to intubate *via* the nose, although one was limited in the size of tube which could be used. A slightly smaller tube was necessary.

The pig was probably the most difficult of animals to anaesthetise and he was very pleased when Professor Mackintosh asked him if he had trouble in intubating pigs because he himself had the greatest difficulty. The pig was undoubtedly the most difficult to intubate, yet it was a case where intubation was required because the animal developed respiratory obstructions remarkably easily. It appeared that the position of the head of the pig was extremely critical and probably more pigs died from respiratory obstruction under anaesthesia than from any other cause.

Mr. Hall added that he had used barbiturates in ruminants very extensively. Although they tended to produce a bronchial spasm in ruminants, he had found them very useful indeed, and for short operations did not bother to intubate. He was, however, also associated with experimental surgery where the procedures were often very lengthy and intubation was essential.

He agreed with Dr. Spreull that packing the pharynx was just as effective as using cuffed tubes. An added advantage was that plain tubes were cheaper and one could keep a much better stock.

In reply to Mr. Jordan, Mr. Hall said he had tried vinylethyl ether. He had used it and shown students its use for the induction of anaesthesia in dogs and cats fairly satisfactorily. He did not like it for any prolonged operation because it seemed that prolonged administration resulted in toxic effects to the liver and kidneys, which had also been confirmed in the human.

He had used pethidine intravenously very extensively and found it extremely useful, but it had the effect, if pushed in too quickly, of lowering the blood pressure.

Adverse Effects on Animal Health brought about by Man's Interference with Nature

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THERE can be no doubt that the arrival of man was one of the worst calamities that ever happened to all the creatures of this lovely earth. Where plants unfold special organs of fantastic design, coloured like the rainbow, scented and nectared that bees may visit them; where the bees are happy in visiting the flowers which are essential to their welfare, and the flowers become fruitful in consequence and renew the stock for the coming year. Everything seems to have depended upon everything else for good, and all to have been balanced and built into an harmonious whole. To quote from a modern naturalist, Jim Corbett, "it was the law of the jungle that is older and infinitely better than man-made laws. The law that permits the individual to live its own life and to anticipate no troubles or sorrows for the morrow."

To-day we are to discuss in what ways man has upset the healthy balance and how he has brought about disharmony where little existed before. Many of my examples will be taken from the field of parasitology, with which I am most familiar, but I shall endeavour, with a view to stimulating a wide discussion, to take examples from other fields where man's activities seem to have caused adverse effects on animal health. These will be dealt with under the headings of "Unnatural Foods," "Unnatural Environment," "Unnatural Concentration of Grazing Animals," "Unnatural Geographical Position," and "Unnatural Animals." Before proceeding, however, with an account of the derangement of the natural order of living things it will be necessary to discuss, briefly, their integration into communities that live harmoniously together and of their natural adaptations that have come about through the process of evolution.

Complexity of Animal Ecology

We are all familiar with the general outline of the theory of evolution and of natural selection through survival of the fittest on a background of the variation of individuals. Many of us have thought a good deal about it from time to time, or may even have worried about the implications concerning our own simian ancestry, but most of us, I venture to suggest, have been satisfied to keep it in that department of our recollections that is also concerned with the story of "The house that Jack built" or of Adam and Eve in the Garden of Eden.

It has needed the work of the ecologists to show us the advantage of thinking not so much of the evolution of a species as the evolution of a world of species all together at one and the same time. During the millions of years of evolutionary development the succession of species of living creatures have been learning how to make use of what is present in their environment, and to make use of one another. They have evolved together into an organised world of living animals that are dependent upon hundreds or thousands of influences in their environment without which their species would become extinct. Before discussing these points, however, we should be sure that we clearly recognise the differences between the concept of "individual" and of "species." We shall not be considering the association of an individual parasite or a multiplicity of individuals with a host, but of a parasite species and a host species, or of a host species with its environment.

Perhaps at this point it would be advantageous to give an example of the kind of integration that I have in mind and of the complexity of relationships within an ecological unit. It concerns the diseased condition of sheep known as "bush sickness," "enzootic marasmus," "pining" and by many other local names, and ultimately traced to a deficiency of cobalt in the herbage. Large tracts of country were concerned and it was a major cause of loss until a chance observation showed that it could be prevented by the administration of iron salts or of earths containing iron. Wide use of a mineral earth called "limonite" revealed the interesting point, however, that certain samples were devoid of this preventive power. A search then began for the detection of the operative substance present only in some samples and revealed the activity of cobalt, which was present only in very minute quantities. Finally the investigation arrived at the surprising conclusion that the cobalt was not required by the sheep at all but only by the bacteria in the rumen on whose metabolic processes the sheep (or other ruminants) depend for the provision of vitamin B12 which is essential for their health.

This example of ecological integration is a good one because the several relationships can be clearly recognised. There is the ruminant and the surrounding herbage that provides it with the carbohydrates, fats and proteins along with the essential salts, and in addition there are the bacteria and the protozoa in the rumen that we now begin to learn are of very great importance in the digestion of cellulose and other constituents of the food, and there is also a special requirement for cobalt in order that certain organisms in the rumen may flourish and during their metabolic processes manufacture vitamin B12 that is essential to their host.

The species *Ovis aires* is therefore seen to be a walking community of species that have evolved together and have acquired a certain dependence on one another. Such observations as this, on the importance of cobalt, can be regarded as windows

through which we may catch a glimpse of the complexity in the relationship of animal organisms to one another and to their vegetable and mineral environment.

Another window has recently been opened through the observation of the effect of the administration of antibiotics in the food. As yet we are very imperfectly informed on the mode of their action but it appears that certain micro-organisms, frequently present in the bowel of normal animals, are responsible for a depression in their rate of growth. Furthermore, reports are now coming in of certain micro-organisms taking on a pathogenic rôle that is contrary to their usual wont, as a result of the suppression of competitive organisms by the feeding of antibiotics. This provides yet another glimpse of the complex relationships that exist as a result of the simultaneous evolution of organisms. It is an aspect of our subject to which I shall have to return when dealing with parasitic disease but at the present I would like to apply this picture of complex ecological relationship to a different field of man's interference,

1. Unnatural Foods

The food relationship is an intimate one and as far as human health goes is a most attractive subject for the faddist. The composters, the raw-vegetable enthusiasts and the eaters of brown bread are to be found everywhere. Like so many of these enthusiasms, however, there is an underlying truth to stimulate the infatuation, which in this instance is to be found in the idea that our artificial purification of foods may lead to the elimination of valuable ingredients that are unknown to us at the present time. The story of vitamins is still only partly told, but it now becomes clear that there are many complex substances synthesised by plants or by bacteria that are essential to the health of the animal body. How it has come about we can only guess but there is an essential connection that is the outcome of contiguous evolution, similar to the association of the bees and the flowers; some matter of species having developed together for millions of years, that has led to the dependence of the vertebrate on the provision of these ready-made substances. It would be foolish to think that we know of half the possible vitamin or mineral or trace-element deficiencies, or that we have a complete appreciation even of the general kinds of deficiences that occur, and much wiser to think there are many more of which we know nothing.

Good examples are to be seen in connection with the recent developments in grassland production through the improvement of strains of grasses and the cultivation of pure strains. Chemists declare them to be markedly superior in the matter of nutritional value and digestibility, but the grazing animals, by the preference that they show for the rough herbage of the banks and headlands tell us of some deficiency that we do not understand. It now seems to be reasonably clear that metabolic disorders concerning mineral imbalance are more prevalent on these unnatural pastures than elsewhere and the value of an occasional movement of sheep, off the "improved" grass and onto the rough herbage in mountain districts is clearly recognisable. The economy of the grazing animal has evolved in contact with the herbs of the field, where it has become dependent upon the substances that the mixed herbage provides. It is an ecological system that cannot be separated, and unnatural food that leaves out any of the components of natural herbage is in danger of leaving out essentials.

Undoubtedly there are many examples of the evil outcome of unnatural foods, there is the farinaceous diet for dogs, the excessive feeding of concentrates to milking cattle, the feeding of unnaturally dry food to pigs—related in some way to irritable skin conditions; the anaemia of young pigs reared away from contact with soil; bloat still remains a mystery, but is clearly associated with unnatural food, and the pregnancy toxaemia of ewes which are unfitted by their primitive mountain development for grazing on our rich lowland pastures is yet another example.

2. Unnatural environment

The first thing to notice here is the amazing adaptability of our farm animals and birds. There is the barn-door fowl that may start as an egg in a thermostatically controlled box, pass through various intermediate imitations of maternal care in outfits called "brooders" and finish in an amazingly cheerful way, confined to a small cell in which it regularly lays its daily egg on sloping bars that cause it immediately to roll away for the exclusive use of the inhuman master. Then there is the sheep that is asked to withstand the tropical heat of Central Australia and the proximity of perpetual snows in the South Island of New Zealand, and does so surprisingly well. It is in the matter of hygiene, however, that we strain the adaptabilities too far. Lungworms and hookworms practically wiped out the Canadian fox-farming industry before suitable adjustments were made to the unnatural environment in which the foxes were kept. Typhoid has been banished from western countries through the excellence of our water-borne sanitation and in a loose way we have concluded that the essential part of all good hygiene is the complete removal of excrement. These ideas, however, may be traditional rather than scientific. I have often wondered at the excessive care of the cat in burying all trace of its excrement, coupled with an even greater care in licking it off the coat and swallowing it. The bullock yard is an amazing example of healthy animals living on a pile of their own dung. But the most up-to-date example is that of the deep-litter poultry house; a most unhygienic environment, so we should have thought, and yet one that has met with a measure of success that is not yet fully explained.

Here we should turn again, however, to the ecological view of living organisms having evolved together and having grown to fit one another and to fit their whole natural environment with perfection. What is natural therefore, is healthy. The two terms are synonymous. The piles of guano where bats or sea birds have congregated for hundreds of thousands or millions of years are not unhygienic in the true sense of the word, being compatible with the well-

being of normal healthy creatures. Although, I cannot pretend to understand the inscrutable practices of the cat I am sure that there are good reasons and that healthy adjustments have been made. What is natural and hygienic, however, for sea fowls and for bats, who live in close contact with the excrement of their kind, is unnatural and therefore unhygienic for the Indian jungle fowl. Their ecology has evolved to fit a different environment and their immunological relationships with the parasites that depend upon faecal contact for dissemination are different. When man crowds them together, therefore, in an unnatural way the delicate balance is upset and disease appears.

The coccidioses of chickens provide a very good example of the upset of the balance through overcrowding. Recent work on the commonest form of coccidiosis in chickens has emphasised the paramount importance of the immunity that each individual must develop for himself, as a result of a relatively light infection acquired in early life. It is of great importance for the very young chick to pick up a few infective oocysts and acquire the resistance that he will need when he happens to pick up a large number in later life. If, however, the circumstances are such that he picks up a large number of oocysts before this immunity has become established the growth of schizonts in the caecal mucous membrane becomes so extensive that death will follow, and that is what happened so commonly where the rearing of chickens was attempted under crowded conditions in the open.

It is a salutary thought that most of our successful adjustments to the calamitous results of our interference with nature are in the first place an outcome of the primitive procedure of trial and error. Such simple ideas as "that it is necessary to use clean ground"; or "that one must be particularly hygienic where young creatures are concerned" lead us to make temporary adjustments that allow us to carry on until the subsequent application of the scientific method has found the reason by which we are enabled to apply our intelligence to the exploitation of the new idea. It is of particular interest therefore that the latest scientific investigations into the control of caecal coccidiosis by hygienic procedures should have revealed the dangers of keeping chicks away from all contact with coccidial infection in the brooder house. If we keep closely to our use of the term "hygienic conditions" as synonymous with "healthy conditions" we must conclude that it is possible to be too clean, and that chickens destined to live in such a parasite-ridden world as this must meet a few in their early life, otherwise they are deprived of the essential preparations for health in the ecological niche that they are destined to occupy.

It would seem, therefore, that an essential outcome of man's endeavour to crowd together a large concentration of stock, in so far as the domestic fowl goes, is the development of the extremely artificial condition known as the "intensive system." The answer to similar difficulties over an unnatural concentration of turkeys appears to be of the same kind; because of the prevalence of disease they are driven indoors where the environment can be more perfectly controlled. Endeavours to produce great concentrations of healthy pigs appears to lead in the same direction, as also the rearing of calves. There is, however, one important department of agriculture in which this extreme increase of artificiality cannot be practised, that of grazing animals and of the conversion of grass into a form of food that can be utilised by man.

3. Unnatural Concentration of Grazing Animals

As the successful grazing by agricultural stock is one of the mainstays to man's continued survival it is of the greatest importance that the relationship between overcrowding and disease should be understood in order that we may be able to make the necessary adjustments. The nature of the difficulties has been the subject of investigation of a mere handful of scientific workers, and it is not surprising that as yet no satisfactory answer has been found.

The trichostrongylid nematodes are the most notable group of parasites in this connection. They are presumably among the oldest parasites, and although the fitness of their adjustments does not reach the perfection of that of the bees and the flowers it is of a very high order such as enables the whole community of grazing animals and worms to live harmoniously together, and assures the continuity of the two species in a common environment.

Investigation of the relationships between these parasites and sheep leads one to suppose that in the natural environment the worm-free lamb, born into a wormy world, would soon begin to pick up a few infective nematode larvae to which it would continue to add as its daily intake of infective grass increased. Because of the distribution of the primitive sheep over a wide area, however, and the consequent light infection of the herbage, there would be little risk of the numbers of worms reaching pathogenic proportions before the lamb was old enough to resist.

This resistance is an adaptation of very great complexity such as we can hardly hope to unravel. The science of immunology gives us some idea of the complexities. When we consider, however, that the relationship as we see it to-day represents the successive adaptations of host and parasite to one another during the millions of years in which they have evolved together it is not surprising to find a difficulty in the understanding. That the resistance should need to be acquired by each individual seems particularly strange. By some slow evolutionary process it has come about that young animals must first acquire a moderate infestation, then throw most of it off as the specific resistance develops, but not all of it, as the resistant adult must carry a few worms to maintain the infection of the pastures. These are the adaptations that enabled the two species to live happily together, and are the disease-resisting mechanisms that have been upset by man.

The main line of interference comes through the unnatural concentration of stock which greatly increases the rate of intake, for it is easily shown that infection tends to increase as the square of the number of grazing animals per unit area. By hedging in

the fields and forcing the animals to eat the dirty grass man has increased the chances of each egg getting back to the host. Our observations on experimental plots have shown that ewes may acquire daily some 7,000 infective trichostrongyle larvae without showing signs of ill-health. Our experimental calves which have once thrown off their infection with *Dictyocaulus* are also observed to be extremely resistant to reinfection. This resistance is a factor of first importance in providing a means whereby grazing animals and their parasites continue to live together in many different kinds of environment varying from such extremely remote contact as to endanger the continuity of the parasite species, to such overcrowded conditions as endanger the continuity of the host species from over-parasitism.

The effect of the age of grazing animals on the concentration of larvae in the herbage is not, however, generally appreciated. There is a very considerable difference between the numbers of eggs per gramme in the faeces of susceptible young grazing animals, and of resistant adults, which variation signifies a great difference between the numbers of larvae added daily to the pastures by animals of these two ages or states of resistance. In making some recent calculations in the Department of Parasitology at Weybridge, a 100-lb. sheep was estimated to be passing 4.8 lb. of faeces during each 24 hours and its lamb to be passing 3 lb. On this basis we have observed groups of diseased lambs to be passing up to 8,000,000 eggs per lamb per day on to the pasture. Ewes, on the other hand, usually pass only some 200,000 eggs per day. In one instance the average rate of addition of eggs to pasture per lamb was observed to be 3,000,000 but of ewes running with those lambs was only 130,000.

Such figures were used to calculate the approximate rate of gain and loss of larvae on pastures, showing that not only can resistant adult animals be substituted for susceptible young ones with advantage, but that even if they are added to those already there the overall result may be a reduction in the infestation of the pasture. The figures used in the following examples are such as have frequently been obtained in the examination of faecal samples from the sheep and herbage samples from the pastures. A lamb grazing where the herbage is carrying 150 larvae per pound, and eating 7 lb. of herbage in 24 hours, will remove 1,050 nematode larvae during that time. If, however, the 3 lb. of faeces that it passes during the period contain 1,500 eggs per gramme, and one egg out of every 1,000 produces a third-stage larva, the lamb will be adding 2,049 larvae daily, representing an overall increase of 999 larvae per day. Suppose a ewe passing 200 eggs per gramme of faeces be placed along with the lamb, to graze the same area of pasture, then at the same rate of development, but passing 4.8 lb. of faeces, it will be adding 436 larvae daily. The average ewe that has been taken as the example, however, eats some 14 lb. of herbage in a day, which at the rate of 150 larvae per pound, represents the removal of 2,100 or a reduction of the infestation of the field by 1,664 larvae per day. Where such a ewe and its lamb are grazing together over the same ground, the net result is to add 2,485 larvae per day, but to remove 3,150, representing an overall decrease of 665, which is a considerable help to the cleaning-up of the pasture.

Although such calculations are of a theoretical nature they are of considerable value in enabling us to understand the trends that result from the various changes to which pastures and grazing animals are subjected under agricultural conditions. The difficulty in reaching reliable conclusions arises from the complexity of the interaction of the several factors some of which operate in two directions at one and the same time; for instance, the factor of short herbage, which tends to increase the rate of the pick-up of larvae (because the sheep bite closer and must cover a larger area to satisfy their appetite), at the same time operates against the success of larval development, because the faeces tend to become dry. In such instances it is difficult to decide which is the more important, and much field experimentation is needed to clarify these points.

Another gap in our knowledge concerns the precise nature of the microclimate in the field. We are well informed on what happens in the laboratory and on the responses of the free-living stages of these parasites to dryness, temperature and oxygen tension, but we know very little of the precise conditions that occur in the field with regard to these three factors.

4. Unnatural Geographical Position

This is man's most notable interference with the *status quo*. Compared with the operations previously described this is big business—upsetting the normal relationships of host species and parasite species on a wholesale scale. Before proceeding, however, I must return to the story of the bees and the flowers and particularise a little over hosts and parasites.

For the purpose of this discussion, as for most other discussions on parasitism, we might dispense with such terms as "symbiosis," "mutualism," or "commensalism"; they have their uses when one wishes to discuss types of parasitism but do not convey anything that is essentially different from the idea of a small creature that secures its food by stealing from another—an interested hanger-on. Bees depend almost entirely upon flowers for their food; it is one of the oldest associations and is the outstanding example of harmless parasitism; a perfection of interdependence, like that of the sheep and the vitamin-manufacturing bacteria. A point that becomes very obvious to anyone who works in the experimental field with nematodes, is that when these ancient and well-adapted parasites are present in reasonable numbers (what we may perhaps regard as natural numbers), they appear to cause little or no harm.

This state of essential harmlessness appears to me to be the ultimate goal of perfection in parasitism towards which all parasites tend to evolve. There is much more in this matter of adjustment of host to parasite and of parasite to host than meets the eye, and although our ideas have now advanced far beyond the simple concept of a multiplicity of small creatures endeavouring to kill a larger one they still

have further to go along the line of realisation that advanced parasitism is a matter of the adaptation of two species, one to another. The knowledge of immunology that the bacteriologists have built up seems complicated enough in all conscience but, as we are only just beginning to realise, the so-called "immunity" probably works in both directions and the question "how does the parasite resist the host?" is as pertinent as the more usual question as to how the host resists the parasite. Somewhere interwoven in this relationship there must be reactions ensuring that the parasite species will not eliminate the host species. It may be argued that such considerations apply only to macroscopic parasites and have no applications in the microbial field; that, however, is not necessarily so. If very old parasite species, such as the nematodes that have developed their parasitism well on the way towards perfection, have acquired such responses as enable them to avoid the elimination of the host species, is it not probable that those parasites which are less perfectly adapted are at least on the way to acquiring those same characters?

It is difficult for us to appreciate the effect of small forces and faint trends operating throughout the millions of years of evolutionary time in which the plants and the insects have developed their host-parasite relationship to the ultimate point of mutual benefit, and at the risk of labouring this point I would like to give an example, as I see it, of the relationship of the nematode genus *Trichonema* to the soliped genus *Equus*. These small nematodes are well-known inhabitants of the large intestine of the horse and the whole ecological unit, if we look at it from the worm's-eye view, consists of suitable soils, of moisture and temperature adequate for the growth of herbaceous plants, and of horses to graze there for the purpose of producing healthy intestines in order that the species of *Trichonema* may thrive and propagate their kind. In the ordinary way these nematodes live for a long time, probably for years; a mechanism is necessary, however, for the restriction of the population, as otherwise their immediate environment, which is the gut of the horse, might become so severely affected that the horse who has produced the gut would die and the whole community would perish.

There can be little doubt that the primitive ancestors of these worms were laying down the foundations for this balance long before the advent of *Eohippus*, the most primitive ancestor of the horse, that palaeontology has recognised. If we begin to search for the mechanism, the first ideas to which we naturally turn are those connected with what we have been able to observe of the immunity that endeavours to overcome bacterial invasion; but those, I submit, should be considered as only a small part of the complex array of forces that have been integrated in that ecological unit of horse, worms and pasture, towards the adjustment of nematode population. There are also very complex responses on the part of the parasites. Gibson's work at Weybridge has shown, for instance, that the mucous membrane of the colon of the horse is only receptive of infection in early life, and apparently only during the time that the foal is receiving mare's milk. Furthermore, that the majority of the larvae then acquired remain in a dormant state in the mucous membrane for months or perhaps years, only proceeding with their full development to make up any depletion in the population of the lumen. This would seem to be sufficiently complicated, but we must also recognise as part of the adjustment that has evolved, the specific responses that cause the horse to avoid the proximity of faeces while grazing and to defecate only in certain parts of a restricted grazing area. It is through all of these many factors that the component parts of the ecological unit are integrated into a whole which operates harmoniously, populations are balanced, and the continuity of the nematode species is assured.

It is not surprising, therefore, that introductions of new parasites to communities of hosts that have not previously experienced them, or the transportation of hosts to parts where strange parasites exist should upset the orderly arrangement of natural things. It is, in fact, by moving things about the face of the earth, as the earth had never previously experienced, that man has initiated a whole host of major troubles. Nor has his own species been exempt, whole races having been reduced to a few straggling numbers by the introduction of tuberculosis, measles and influenza, to the unfortunate inhabitants of the distant parts where those infections were unknown.

Among the domestic animals no better examples could be found than those of trypanosomiasis and East Coast Fever, which infections have only appeared as devastating diseases since the introduction of foreign animals devoid of the essential adaptations that have been acquired by the native ruminants during their long evolutionary association with the responsible parasites. Babesiosis is an interesting example in that its influence may be localised to relatively small areas wherein indigenous cattle grow up with a resistance that imported cattle lack. It seems likely that swine fever as we know it is also a disease of an introduced species of host, consequent upon its contact with a virus of the American peccaries, and virtually certain that the still more severe form of disease known as African swine fever is caused by a virus well tolerated by the wart hog but ill-adapted to the newly introduced host.

So much for the movement of hosts about the face of the earth; the movement of parasites has caused similar trouble, and we seem to be justified in concluding in a general way that when a parasite is particularly pathogenic the probability is that it is in an unnatural host. The American parasitologist, Ransom, in discussing the pathogenicity of the gapeworm to turkeys some thirty years ago, expressed the opinion that it was very possibly a North American parasite introduced into Europe. On the same grounds it is reasonable to suppose that *Histomonas meleagridis* which is so relatively harmless to chickens and so fatal to turkeys had not met that host until it was brought over from America by man. This exchange of parasites, *Syngamus* for *Histomonas*, between two species of birds that had not

previously come into contact with one another in the history of the world was a most unfortunate occurrence for both species and was brought about by the agency of man.

There are doubtless many other diseases due to the presence of parasites in the wrong host—psittacosis virus in man instead of in parrots, bubonic plague in man instead of in rats, encephalomyelitis virus in horses instead of wild birds or myxomatosis virus in the European rabbit instead of the allied species from South America. This last has been a most striking example. In the amazingly clean sweep, bordering on the eradication of the host species, we can clearly see the possibilities of such a badly adapted virus leading to its own elimination through the disappearance of the host. Newcastle disease provides another example of the uncertain position of a virus that is too pathogenic. When this disease first appeared in 1926 its effect was so severe that whole flocks of fowls were completely wiped out, and what threatened to be an exceedingly troublesome new form of epidemic disease was eliminated spontaneously through extreme ill-adaptation of host and parasite. We may surmise that here again we were dealing with a parasite (or a virus) in the wrong host, a virus that may be well adapted to some species of wild bird but that through some accident or unusual circumstance had been transmitted to a community of domestic fowls.

We may suppose, however, that viruses change their ways very much more rapidly than do the old and well established metazoan parasites and in the modifications that are now taking place between the European rabbit and the myxomatosis virus we can see the operation of the mechanisms of adaptation. A certain small number of rabbits have a greater resistance than their fellows and tend to produce progeny of like kind. Avirulent strains of the virus are also beginning to appear and it becomes clear that adaptation will ultimately supervene and both the rabbits and the virus will survive.

5. Unnatural Animals

Man has succeeded in modifying the outward form of many plants and animals and in some few examples has been able to improve on what natural evolution provided. It would be an indictment however, to catalogue the horrors slowly and intentionally produced by his relentless selection in the canine world. Instead of that fleet, friendly and happy creature the wild dog we see animals that can scarcely run because of the absurd proportions of their legs and body, others half blinded by an overgrowth of hair that covers their eyes, and worse still, some that die of suffocation because of too long and pendulous a soft palate; or that must suffer an amputation in order to be able to perform the act of defecation, or that experience great difficulty in parturition because of the unnatural skull of the offspring. This seems to be one of the places where we should join forces with the humanitarians and direct our skill to the elimination of monstrosities that are a slight on the dignity of the dog and ridicule the only friend that man has won during his sojourn on the earth. Should we not make a protest against these outrages? That plea is only an aside in our discussion, however, as we are dealing to-day with disease that is a nuisance to man as well as to the animal itself. It is, however, of interest to those in canine veterinary practice, that while selecting for short legs, short nose, or long coat, man has also unknowingly been selecting cankerous ears, irritable skins, and a pendulous soft palate that occasionally leads to asphyxia.

The cow and the hen can also blame us bitterly, although the hen, being hardier, has suffered less in health from the over-development of her reproductive functions and apart from occasional orgies of the most terrible cannibalism puts up with the change. The cow, however, suffers considerably as a result of her excessive mammary development which has greatly increased the susceptibility to bacterial invasion and through physiological hyperfunction leads, at certain times, to derangement in the balance of salts in the blood.

There are doubtless many other ills associated with unnatural animals but an interesting parasitological ill, traceable to that cause, and one that would take a very prominent place had draft horses retained their importance, is the unnaturally favourable environment afforded by the hairy legs of shires, in particular, to persistent infestation with *Chorioptes equi*. The late Noel Pillars, who at one time was responsible for the health of a large number of heavy draft horses in Liverpool, maintained that "itchy legs" was responsible for greater economic loss where these animals were concerned than was any other condition.

Another parasitological example is that of sheep scab which has only become a fatal disease because of the unnatural density of the fleece of our man-made sheep; the shelter and absence of light being such as to alter the microclimate and disarrange the adjustments of host to parasite. Although widespread in countries where hairy sheep abound this parasite may give rise to considerable irritation, to be regarded, however, rather as discomfort than disease.

There is no time to follow this sad story of unnatural animals, and the waltzing mice, with their cerebral or cerebellar abnormality, the lop-eared rabbits, the deformed pigeons (some of which are incapable of rearing their own offspring) and the list of flightless birds can receive no more than a mention.

The Borderline of Health and Disease

Finally, what can be done about all this derangement? One thing is clear, there is no going back to the natural state; the human population has increased to such a point that methods of producing food must go on improving in a very unnatural way or we shall starve. In this artificiality we are skating all the time on thin ice as we do not completely understand the nature of the laws that we are breaking nor can we foresee the new troubles that each fresh line of interference is likely to call forth. The latest example

of the unexpected results of our meddling is the pathogenic rôle that may be assumed by some ordinarily harmless micro-organisms following the continued internal use of antibiotics, to which reference has already been made. Particularly do we seem to be running a risk where helminthic disease in grazing animals is concerned, the increasing improvement of our pastures and consequent increased concentration of stock tending continually towards an increase of worm population. It is indeed fortunate for the success of our present endeavours that the immunity acquired by the grazing animals as they grow to maturity, acts as a buffer and provides them with a means of resisting stresses that are considerably greater than they would normally meet under natural conditions.

It is by gaining knowledge of such factors as this, and acquiring an understanding of the forces that have operated in maintaining the necessary balance among the communities of organisms, both outside and inside our domestic animals, that we shall be able to make the proper adjustments in order to maintain health under our increasingly artificial conditions. The time for the eradication of harmful organisms has only begun, but it will be an urgent work of the future in an endeavour to face the need for balance between world population and agricultural produce.

Summary

The idea of the evolution of living things through the process of natural selection implies a constant trend towards better adaptation to environment. Plants and animals have learned to make use of whatever has been constantly present in their surroundings and many of those factors have become essential to their well-being. The matured position as seen by man is one in which the natural is the healthy, and the unnatural is often the unhealthy.

Man's activities have brought about many changes in the environment of the animals that he has domesticated and many kinds of ill-health have resulted. These conditions are discussed under the following headings: "Unnatural food," "Unnatural environment," "Unnatural concentration of grazing animals," "Unnatural geographical position," and "Unnatural animals." Finally, it is concluded that the maintenance of health and the satisfactory increase of animal production can only come about through enhanced artificiality for which we must acquire an understanding of the forces that operate in maintaining health under natural conditions.

THE SPEAKER'S INTRODUCTION

The Chairman, Professor H. G. Lamont, called upon the author to introduce his paper.

Dr. Taylor said: "My paper has exceeded the 5,000 words allowed to me by the Secretary by some 2,000 words, and I suppose I ought to apologise for that, but when I began to warm up to the subject I could see its enormous field. One could discuss almost every aspect of animal disease under this title and I think now that the paper is really very much too brief altogether. It has endeavoured to cover too much ground and on that account suffers from over-simplification. For instance, you may have got the idea that I thought that in primitive times everything was perfect bliss and that everything was all the time healthy and nothing bad ever happened. That is not so at all. Individuals, I am sure, must have suffered very greatly. An individual gazelle, for instance, would always be in danger of its life if it was anywhere near a tiger; nevertheless, tigers in the mass might have been very good for gazelles in the mass. If the tiger control is removed, ruminants become too numerous and gazelles are crowded out, so the two species, tiger and gazelle, are good for one another, though individually they are not.

"You may also have got the idea from my over-simplified treatment of the subject that I consider parasitic worms never to have caused any harm in primitive times. I do not think that; what I do think is that under our modern agricultural conditions they cause very much more harm all the time than they used to do. I suppose that in primitive times there must have been a lot of what I should like to call parasitological accidents. Perhaps in game-infested country once every 25 years there would be a drought which would cause the animals to concentrate on the small areas of pasture that were still green, and I imagine that might have resulted in extensive loss amongst the herds and flocks as a result of unnatural concentration. The possibility of certain parasites getting into the wrong host must have quite often happened in birds at any rate because of their great mobility. I have come across a few instances in my own experience of wild birds, of sea birds, for instance, beginning to feed on fresh-water lakes, and picking up parasites which do not really belong to them. They may then suffer very severely from their association with unadopted parasites. My paper deals with the upsetting of natural conditions. It endeavours to present the pattern of balanced communities during the period of evolution. We are now substituting a new pattern, the pattern of progress which, I think, so far as animal disease is concerned, goes on in the following kind of way. First we find some better method of growing crops or of producing animals, to make them larger or their reproduction more frequent; we then use that new method extensively; presently we find that disease is beginning to appear. We investigate the disease and find out how to put it right by some adjustment made by artificial means. Another innovation comes along—in another direction perhaps, and we do the same sort of thing all over again. Our only hope for the future is more and more artificiality—finding out precisely what we have done to upset the balance and then how to put it right again.

"Finally, I should like to show two slides in order to clarify a few figures which appear in my paper and which I thought may not seem quite clear without being shown in the form of a table."

Dr. Taylor then showed the two slides which he said illustrated a step in the investigation of the upset in host-parasite balance, resulting from the man-made circumstance of the crowding of stock into pasture land.

The Opener

Mr. G. N. Gould (Southampton): "I am privileged to open the discussion on Dr. Taylor's paper and in congratulating him may I also thank him on your behalf for his many contributions to the activities of the B.V.A., not the least of which is his work—continuous since its inception—on the Technical Development Committee.

"He has presented a most interesting theme—the impact of environment on animal health—and in doing so has peered through a number of windows which I would rename: nutrition, animal behaviour, grassland management, parasitology and genetics, in effect, the study of Animal Husbandry—a subject of outstanding importance in veterinary science. He has also drawn attention to, and instanced the power for, radical change in environment placed at our disposal by modern chemotherapy.

"The paper is presented in his characteristic style, on this occasion with that suggestion of whimsy which makes it more attractive than usual.

"You will agree it is unusual for a research worker to commit himself so categorically as Dr. Taylor has done in his opening and final paragraphs. This, I believe, really reflects his wide field experience, in that he is in fact recording his impressions—a perquisite of clinicians—

some of whom have been accused of repeating them with such conviction as to have them accepted as proven fact. While it is true that we must acquire an understanding of the forces that operate in maintaining health under natural conditions, it must be remembered that farming practices have departed throughout the ages so far from one's conception of the term "natural conditions" that a fuller understanding of these practices in all their diversity is essential in veterinary research and practice. The two are complementary.

"In the discussion of a paper covering such an enormous range, I, as a clinician, must inevitably rely considerably upon impression.

"I have given much thought to the 'healthy balance' of nature and have come to the conclusion that it is a catch phrase since the backwaters of the evolutionary flood balance, if it ever existed, have been ever changing—due to varying environmental factors. Man's part has not only been that of inducing further changes in his struggle to survive and to provide for his well-being, his comfort and his recreation, but to provide protection against harmful environmental factors where his knowledge is adequate.

"At the B.Y.A. Grassland Conferences it has been stressed over and over again that every innovation in method or management is likely to bring its own particular problems. The fact that changes in environment—often radical—are made when seasonal alterations in management and new techniques or methods are introduced, is too little appreciated, and rarely provided for until loss of production or ill-health arises.

"Dr. Taylor's paper indicates the strain or stress on the balancing mechanism of the farm animal imposed by modern requirements of productive capacity—that over the centuries there has been a continual struggle by domestic animals to adapt themselves to changing environmental factors imposed by changing managements and methods—and that in the last two decades, in this country in particular, when changes have been so many and so great, new problems have been precipitated. With this we all must agree.

"It is our responsibility to aid the animal in its adaption—to attempt to foresee and to forestall problems likely to arise when new methods are introduced. On reflection, surely more of our more recent problems of animal health should have been foreseen?

"Dr. Taylor provides an example of our present-day problems when he refers to the administration of antibiotics in food, of which 'we are imperfectly informed of their mode of action'—and of reports indicative of 'certain micro-organisms taking on a pathogenic rôle that is contrary to their usual wont as a result of the suppression of competitive organisms.' The need for further understanding, particularly in view of the extension to antibiotics of wider range is surely urgent, particularly now that high level antibiotic feeding—the dividing line between which, and actual treatment may be very indefinite—is the subject of popular clamour.

"These reports are consistent with those in certain hospitals where new patients are exposed to the almost certain risk of infection with resistant strains of organisms as a sequel of the widespread use of antibiotics, the only response being to the very new types of antibiotics not previously used.

"An example closer to us is the remarkable change in the types of clinical mastitis met in those herds and practices where penicillin has been freely used over the years to control or eradicate *agalactiae* mastitis. This was recorded in 1951 in a paper to the Society of Animal Production stating that the mastitis referred to was of much severer type and that penicillin was completely outmoded in treatment. Others have had the same experience. While fully convinced of the high efficiency of penicillin in the control and eradication of *agalactiae* mastitis, our problem to-day is different. Recourse has had to be made to antibiotics of wider range, to hibitane, to the sulphonamides, and as far back as acriflavine in individual cases to secure recovery of prevailing types of mastitis.

"Yet the solution is surely in environmental factors, management and methods. For instance there is almost universal use of the milking machine to-day. I—with others—have the firm conviction that certain types of teat liners introduced in the last few years are associated with a much higher incidence of teat damage and often reduced milking efficiency, with consequent clinical mastitis. More developmental work is required on the further improvements of the milking machine; reliable as it is to-day, it can undoubtedly be still further improved. In addition, methods of cowshed and dairy hygiene need overhauling in the light of experience and knowledge. There is some considerable support for advising against the use of hypochlorites and quaternary ammonium compounds for application to cows' teats. Their use and efficiency should be properly assessed.

"I consider Dr. Taylor's examples of unnatural foods as problems of nutrition. Modern grassland has made an outstanding contribution to 'facing the need for balance between world population and agricultural produce.' It is important to realise that grass is the biggest, the most important and productive of world crops, that its species are many and varied—more particularly according to environment—to which, as a crop it is remarkably sensitive. I think it would be readily agreed that grassland management has not kept pace with grassland improvement. The variability of the crop throughout the year, together with its known response to varying factors, which may be expected or made to operate, make its management a skilled job it would appear to demand radical specific supplementation from time to time. Palatability, fibre, allergies, major and minor mineral deficiencies, metabolic disorders—are all becoming a little more clearly understood, but much more teamwork between veterinary and other sciences, ancillary to agriculture, is essential. Not the least of this work is that open to veterinary surgeons in practice who see results.

"I am not impressed with Dr. Taylor's opinion as of 'herbs in the field' and the 'danger of leaving out essentials' if they are not present in pastures. They are undoubtedly of lower productivity than grass or clovers and as such have no room in our modern agricultural economy unless there is real evidence to support their alleged value. I do believe, however, that in the case of the dairy cow, the man who can make sterilised bone flour palatable will confer untold benefit on future health problems and production, because the most efficient source of the two main mineral elements available is bone flour.

"The dog is no longer a working animal or one hunting its own food. On a natural meat diet, many would become intolerable as household pets.

"Excessive feeding of concentrates to milking cattle is simply indicative of bad management, although I agree that statistics indicate wasteful feeding. The theory of diminishing returns really operates and at £35 per ton, soon makes such management totally uneconomic. I am more concerned at the lack of appreciation of the value, in economic milk production, of a high quality maintenance ration—particularly of hay.

"Skin trouble associated with the *ad lib.* dry feeding of pigs, which arises from time to time is recognised, and its cure by change to a wet diet is known. It would be valuable to know more about it—it might be a pointer to problems in other species.

"Anaemia of young pigs is the problem of the rapidly growing piglet, and can occur even in piglets in contact with soil. It has been fairly well understood for years, but it is only recently—since the introduction of iron fortified supplements for feeding to piglets which are remarkably co-operative in taking them from a shallow receptacle—that really rational methods of control have been devised, and more rapid weight gains without loss have resulted.

"While bloat may still be a mystery, its incidence appears to be on the decline, apparently as a result of a better understanding of potentially dangerous pasture and a reduced tendency to graze very immature pastures. So-called allergic bloat with its tendency to become a problem on certain farms and often in certain specific lines of breeding on these farms is the biggest and most difficult problem.

"Recent information in respect of pregnancy toxaemia of ewes has been a considerable contribution to the elucidation of this problem and of other conditions in sheep, which are making a speedy advance into every practice with the expansion of the industry and its changed outlook.

"Under unnatural environment the essayist has drawn attention to the remarkable adaptability of farm animals and birds to domestication. It has been argued, and he agrees, that often the modern chicken has only known confinement. The battery system does obviate the worst and most cruel vices which occur under other systems of management, and under good management mortality is lower, egg production and bodily condition higher. As far as we are capable of assessing, the birds show no evidence of mental cruelty.

"All highly intensive systems, however, have the same danger—the ease with which breakdown can occur under faulty or bad management. It is true that in the poultry industry, man's endeavour to crowd together a large concentration of stock has driven them indoors where the environment can be more perfectly controlled.

"If one considers pasture not only as a source of grazing but as a habitation for interrupted periods of the cow's life, the solution of grassland problems would appear to lie in grassland management. I am less concerned with high concentration of stock on pastures than with grazing the same stock, or stock of the same species, for prolonged periods—particularly in those years when weather conditions favour persistent grass growth. In other years, the limitation of grass growth dependent on the season is the safety factor. Management providing home paddocks used for calves, the night pastures persistently used for the dairy herd to be at hand for morning milking, the division of the herd into too many, often unnecessary, groups of animals grazing different pastures so that little or no rest from stock is possible, the failure to provide against 'run back' in strip grazing by bringing up a back fence at regular intervals of five to seven days and the return to pasture rotationally grazed at an interval of less than one month, are all in my experience associated with a high incidence of husk infection. Modern grassland, in my experience, appears to demand the maximum concentration of stock for a reasonably short grazing period, followed by rest to recuperate and weather.

"I am not very impressed with the immunity derived by the average bovine to husk infection other than that following recovery from a clinical attack. The extraordinary way in which a closed herd—consisting of animals of varying ages from the first calf heifers to the 14- or 15-year-old cow all commence to cough at precisely the same time in herd outbreaks of clinical parasitic bronchitis, which are the prevailing problem, does not inspire me with confidence in the theory of immunity being derived by the adult animal from repeated intake of larvae when younger, which lead presumably to moderate but not clinical infestations under average farming conditions.

"I was particularly interested to note publication of an article in which Weybridge had investigated a preparation used in treatment. I have the impression, and would like to be sure that it is correct, that the combination of carbon tetrachloride in oil and an antihistamine injected subcutaneously is useful, allied to rotational grazing and the requisite nursing of the more severe cases.

"Dr. Taylor has detailed certain unnatural animals. It is probably true to say that the problems in the canine world arise from breeding being dictated by 'the fancy' rather than by working or productive qualities. The breed societies concerned, together with the controlling body of dogdom—the Kennel Club—are clearly those with the responsibility. We as a profession would, I am sure, willingly make available information and advice.

"The development of the udder of the modern cow is a pre-requisite of her productive capacity. Bad conformation of udder and teats is a much more important factor in ill health and lowered production and this is usually a genetical problem.

"We see in some of the machinery in use on the farm to-day the beginning of the era of automation. Livestock would appear to be an essential corner-stone in the maintenance of soil fertility and the provision of foods of animal origin. We can expect the introduction of many labour saving techniques—they should be considered in the light of the economy of the individual farm with due regard, not only for the great diversity of British Agriculture, but for the changed environmental factors induced and possible health problems arising.

"Recognition of health problems arising from changed environment may take a little longer than the immediate economic production benefits claimed by sponsors of new methods. It must be fully realised that modern production methods impose periods of great stress—sometimes sustained, but more often sudden and short—which are frequently associated with a breakdown in the balancing mechanism of the animal resulting in ill health. Many of these periods of stress are known and understood, others hardly appreciated. Careful field observation can be of great value in the general study of these stresses. It must be realised that the productive life of the dairy cow is lengthening and we shall soon be dealing with problems of old age.

"I have every faith in the modern farm animal. I believe we, as a profession, have much to contribute to the elucidation of existing problems and of those which will undoubtedly arise in the future through continued increase in agricultural production.

The Chairman said that all local veterinarians knew Professor Baskett. For those who had not the good fortune to have contact with him he would say that Professor Baskett was Head of the Agricultural Chemistry Department at Queen's University. He had a great deal to do with soil and the nutrition of soil, a subject Mr. Gould had raised. Those at Stormont had been very fortunate in having him to help and advise them on many problems, and everyone looked forward to hearing his contribution.

Professor Baskett (Queen's University, Belfast) said that he was in a rather difficult position. Dr. Taylor had added amendments to the paper, Mr. Gould had added his contribution, and now he himself came along almost as the fifth wheel on the wagon. On reading the paper he had realised that from time to time it is very wise to hesitate and glance backwards to look at the main features of the road on which we are travelling. Dr. Taylor had that morning drawn attention to some of these features and had done so in a most admirable fashion. His examples of the adverse effects on animal health caused by the activities of man were pertinent and put forward in a very forceful manner. Many of them were from the field in which Dr. Taylor was of course an undoubted master and the paper was couched in language which revealed a love and understanding of nature.

As an agricultural chemist, Professor Baskett felt some trepidation in contributing to the discussion and hoped he would be forgiven if he confined his remarks to those aspects which touched on questions of nutrition. He would try to avoid over-simplification of a very difficult problem because they were considering the results of the interaction of many different forces.

There were two points to be borne in mind. The first was that the author was dealing with the adverse effects on animal health, and the second, which came towards the end of the paper, was that he said there was no going back to the natural state. In other words, he had purposely omitted any account of what stood to the credit of man with regard to animal health and the scientific and technical knowledge at their disposal in combating present and possible future problems in animal disease and animal nutrition. A point made by Mr. Gould already was that the whole *raison d'être* of agriculture as it was known to-day was to supply food and fibre for the benefit of mankind. The pressure of population demanded increased production and since there were no longer any great areas of land in the world which could be developed they must look to higher productivity per acre and more intensive livestock production to feed the expanding populations.

Indeed, production had increased in a phenomenal manner and with increasing tempo in the last quarter of a century. On the plant side they could recognise three factors which had been mainly responsible for this. First of all there was the increased and more skilful use of fertilisers, second there was mechanisation on the farm, and third there were the advances of the plant breeders, perhaps the most notable of which was the introduction of hybrid corn in North America. Some 80 or 90 per cent. of the corn in the United States now came from the hybrid corn seed and it had resulted in a 25 per cent. increase in yield.

Equally spectacular increases in productivity had come from livestock. The paper left one with the impression,

an impression Dr. Taylor had modified that morning, that man was responsible for the production of an unnatural animal and that the adjective in itself implied censure. Surely what man had done was to select and develop animals which could produce and survive in an environment chosen by man as being suitable for his purpose for the economic production of food. In doing so, man had encountered many pitfalls, notably those associated with disease and lack of knowledge of nutritional requirements. There was something to the credit of man, in his provision of shelter for the animals and of freedom from hunger and the ravages of disease and predators which under natural conditions kept animal populations in check.

If they could ask the ordinary pig on a farm or the dairy cow whether it would like to go back to natural conditions or enjoy what man had provided for it, there would be little doubt as to what the answer would be. Furthermore, in recent years there had been very considerable additions to knowledge of animal nutrition, particularly in regard to the mineral and vitamin requirements of farm animals. Professor Baskett said he would agree that the application of some of these advances had tended to lag a little behind.

The paper referred to cobalt in the provision of vitamin B_{12} as a fascinating example of ecological integration. This example might also have been used to reveal how research had made possible the production of mutton and wool from large areas where it was economically impossible before. Similarly, the discovery that excess molybdenum was the cause of very severe scouring in cattle, and that the feeding of copper salts prevented it, had brought much unsuitable grazing land into full use. While they knew the practical cure, they of course lacked exact knowledge as to the way in which copper salts mediated the effects of molybdenum. Fifteen years ago they were inclined more or less to dismiss vitamins with a passing reference to vitamin A and vitamin D, but investigations had demonstrated clearly the practical importance of others, notably B_2, in the diets of both pigs and poultry. More recently it had been demonstrated that vitamin E deficiency could become a practical problem in the feeding of farm livestock.

The paper drew attention also to the metabolic disorders in grazing animals associated with the highly fertilised pastures containing new strains of grasses and clovers. It was true that up to the present there was no satisfactory explanation of conditions such as grass tetany and the question of palatability of young luscious grasses was equally puzzling. Nevertheless, research would eventually provide an explanation of such difficulties and they should not be allowed to obscure the three-fold increase in the yield of nutrients per acre and the extension to both ends of the grazing season.

Professor Baskett recalled that it was in 1952 that he attended a conference in Chicago at which the question of bloat in cattle was discussed. During the course of the conference one speaker drew attention to the fact that ladino clover was held to be responsible for many outbreaks. He pointed out, however, that the increased productivity resulting from the widespread use of ladino clover far outweighed any losses which it might conceivably have caused. Professor Baskett was not suggesting that they should necessarily accept this view, but he asked for a balanced approach which weighed increases in productivity against problems which might arise. That did not imply for one moment that there should be any relaxation of research into these problems.

Regarding the use of antibiotics in animal feeding, he happened to be in the United States when this moved from the experimental stage into farming practice and was amazed at the speed with which the movement took place. They all knew how cautious had been the approach in Britain and in other European countries, notably Holland, but they could now look back on several years' experience and it would seem that under ordinary farm conditions the feeding of antibiotic supplements would in the majority of cases give rise to an increased rate of growth in pigs of the order of from 10 to 15 per cent. with a smaller but still significant increase in food utilisation. In the past five years many experiments had been carried out at the Agricultural Research Institute at Hillsborough and in all cases the carcases of experimental pigs had been examined and measured at the factory. So far no evidence had been obtained of any adverse effect on carcase quality following the feeding of antibiotic supplements.

In America the feeding of antibiotic supplements was almost universal for poultry, particularly in the so-called broiler industry where birds were kept under very intense conditions and disease control was of paramount importance. They were also widely used in rations for laying birds. In this country the response to the feeding of antibiotics to poultry had not been so spectacular, possibly because the majority of our birds were not kept under quite such intensive conditions as in the United States.

In making a plea for a better understanding of the forces which operate in maintaining health and production in farm animals, Professor Baskett was at one with Dr. Taylor and Mr. Gould. Many problems confronted them but there were now many novel techniques which should aid them in the solution of those problems. They should glance back over the past few years and think of the new tools which had been put in their hands. There was the spectrograph which enabled them to make quantitative measurements of substances which would have baffled the chemist of 20 years ago. Then there was chromatography, making possible the separation of the most complicated systems, and the use of radio-isotopes which had opened up a completely new approach in metabolic studies.

Early in the conference they had heard many interesting accounts of the progress made in the surveys which were being carried out regarding the incidence of disease in farm animals. There were also surveys being made on the husbandry side. Although those surveys were in their early days at the moment they were disclosing that the standards of nutrition and general husbandry were lamentably low, and they were forced to the conclusion that if existing knowledge could be put into practice it would be reflected not only in the improvement of the health of farm livestock but also in increased production and profit for the farmer. It was notably in the borderline area between health and disease that impaired production and low profitability existed.

The General Discussion

Mr. T. Barton Mann (Weyhill) said that he had read the paper with great interest and thought at first that the author was writing rather with his tongue in his cheek for it hinted at very many things. If they were heading for more artificiality in the nutrition of stock, having regard to Professor Baskett's work of some 30 years ago, it might be that the pendulum would swing back to more natural methods. Although living across the water, he had been a great follower of this work, and that perhaps was a natural inclination because his mother came from Ballymena and his father from Armagh.

A paper was published at the Fourth World's Poultry Congress under the names of Prentice, Baskett & Robertson (1930) with a view to getting the Northern Ireland farmer to use more of his skimmed milk and home grown grain for poultry. The experiments showed that far better results were obtained by going back to this more natural form of diet than by using complicated diets containing fish meal.

Having worked on the nutrition of farm stock, Mr. Barton Mann wondered, when told they were feeding their stock on *good* foods, how much of the *goodness* of the food was responsible for a tremendous amount of harm. Although Dr. Taylor had traced man's interference from early days to the days of cranks and faddists, he would refer to the wise precaution of the Mosaic Law that no animal was to be slaughtered that had spot or blemish. This law had had a very important bearing on the New York poultry market and had led to important research in the American broiler industry, for the Jews demanded table poultry of the yellow-skinned and yellow-shanked breeds, knowing full well, and this could easily be substantiated by anyone who spent any time at the *post-mortem* table, that if a growing chicken of the yellow-shanked breed had white shanks, there were plenty of spots and blemishes inside it.

This aspect of the broiler industry had been the occasion of a great deal of research. Culton & Bird (1941) presented evidence that certain poultry feeding stuffs, meat meal,

fish meal and soya bean meal contain a factor or factors which prevent the utilisation of carotene. Fraps, Meinke, Reiser & Sherwood (1943) stated that samples of meat and bone meal, meat meal, fish meal, dried skimmed milk and buttermilk may have a high consuming power for carotene. His own work (Mann, 1945; 1946) showed the destructive action of certain fish meals to vitamin A *in vitro* and *in vivo*. Black, Jennings, Morris & Palgrave (1954) showed the depressant effect of a white fish meal on hatchability. Their analyses of eggs showed that with increasing content of this fish meal in the diet, there were decreasing quantities of xanthophyll, carotene, vitamin A and riboflavine passed to the egg. Again, his own work (Mann, 1945) showed that if chicks were only slightly infected with *S. pullorum*, the infection could be aggravated to epidemic proportions varying from 20 through 40 to 66 per cent. mortality as the total protein intake was increased. Nine years later, Williams Smith (1954) showed that it was very difficult to produce *S. gallinarum* infection in chicks when the diet consisted of whole wheat but that when 15 per cent. fish meal was added, mortality was severe from the disease whether relatively small or large numbers of organisms were used to infect.

In Britain, where the consumer favoured the white-shanked breeds of table poultry, the effects of these depressants in diets were apt to be overlooked. He did not think that there was any question that the inclusion of some of these substances in present-day diets served as a source of interference with the assimilation of certain essential nutrients, and indeed aggravated latent disease to epidemic proportions. There was need to consider this link between feeding and disease, for it would seem that the inclusion of such substances, which were positively harmful, also had an effect upon the intestinal flora, so that it was now necessary to turn to antibiotics to redress a wrong that should never have been permitted in the first place.

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The Chairman said that he might add a word on things that had been discussed at his laboratory, particularly by colleagues from the African colonies. One research worker who visited the laboratory said that trouble with mastitis in the native cattle was not experienced until milk production was upgraded by crossing these animals with various types of European cattle. The inference seemed to be that mastitis rarely occurred in the native cow until her milk production was stepped up. It was only in comparatively recent times that the cow was bred to produce the immense quantities of milk that man's artificial mode of life to-day demanded. However, nature did provide the cow with four teats and she produced only one calf as a rule.

The development or upgrading of the cow had brought about quite a number of conditions which might, and he mentioned this with some trepidation, in view of the scientific people present, be considered as stress phenomena. The development of increased milk production and the improvement of grassland had brought new problems. These were the hypomagnesaemias, the milk fevers and the acetonaemias—all these things might be found to be linked with stress phenomena or hormonal imbalance.

They were becoming increasingly conscious of the very great importance of such things as carbohydrate metabolism. It was not a question of insulin control alone, the adrenal cortex also played a part. Knowledge in that field was expanding every day. Calcium treatment might become outmoded. People who had studied antibiotics had recommended their use in the " short-lived " animals. They were originally intended only for bacon or pork pigs that were to live a short life and for fattening poultry. The laboratory was experiencing a greatly increased number of " scours," despite the antibiotics, and the usual pathogens were not being found. The extension of the life of the dairy cow was a rather significant thing and it might create problems. Statisticians said that the human race was getting older, and the same thing might apply to cows.

The feeding of skimmed milk to pigs was hardly natural and at one time in Britain it certainly led to tuberculosis. That particular condition was now controlled by various unnatural means such as pasteurisation. On the whole they seemed to be progressing despite the gloomy prognostications of Mr. Barton Mann.

Mr. E. R. Callender (Lytham) asked whether the character of mastitis was changing and, if so, should there be recourse to acriflavine because of penicillin-resistant strains or because the course of the disease was altering?

Miss O. Uvarov (Cobham) said that she wished to express her thanks for a very valuable paper—to Dr. Taylor for giving a very broad outlook on the problem, to Mr. Gould for bringing the discussion to a level at which most of them could join in and to Professor Baskett for being what he called the fifth wheel, and giving a balanced approach to the whole problem.

Could Dr. Taylor say, as antibiotics were one of the substances quoted as being used in meddling with nature, whether there was proved evidence that there was in fact a changing pattern of disease due to the use of antibiotics? It was very easy to blame a large number of therapeutic substances, being used in practice, for bad results or the changing of disease. However, the people who discovered and worked on antibiotics were the last to recommend their wide and indiscriminate use, it was once again up to the clinician to use specific substances for their specific action. That was brought out quite forcibly, and more would be heard about it in a later paper. It was still up to the clinician to make his diagnosis first, and then to use antibiotics or other therapeutic substances. If mastitis was changing, and it was known that it was to a certain extent, was this due to a periodical change in pattern of disease, or due to our own fault and the therapeutics employed?

The Reply

Dr. Taylor said he felt that his task of replying was made none the easier because the general discussion had been so brief. He did not know whether to conclude that the subject was too wide, or perhaps that he had failed to indicate lines for discussion. One might have expected the discussion to be a kind of " free for all," the field being such a wide one, and that examples would occur to many people of a variety of disease conditions brought about by interference with nature.

Mr. Gould and Professor Baskett had dealt with him very kindly and he must thank them for that. To go back to the pattern of progress in agriculture, what they did was to find some improvement—some way of producing more herbage on the pastures of an improved kind, or some cheaper way of bringing out a food, or a way of getting animals to grow more quickly. This was extensively applied and then presently it was observed that something unforeseen had happened; animals were not doing quite so well as they ought, a certain amount of infection was getting in or some trouble was more prevalent than it used to be, and it was realised in the end when the trouble was investigated thoroughly that it was due to something involved in the change that had been introduced. There were then efforts to make adjustments. That was what was happening all the time.

The paper dealt really with the first two parts of that pattern of progress, the upset, and the observation that something was wrong, but the openers of the discussion had dealt entirely with the latter part, the artificial adjustments which they were able to make and which had been made. Both Mr. Gould and Professor Baskett rather went along the line " Surely we have improved animals. Look

how much better they are, and see how much more we can now produce." That was quite true, but nevertheless, the ills they had to deal with as veterinarians were the results of the changes made, and that, after all, was the subject of the paper.

They were very successful in this period of progress and would no doubt continue to be. As veterinarians they were concerned with all three branches of progress, with advising on ways of improving animals, with observing the ills that resulted and with putting the ills right, and the more they could look into the future and look ahead the better off they would be.

The thing that was coming along all the time more clearly was the increasing importance of the prevention of disease. That appeared to be the veterinarian's field of the future. It was difficult to know how to fit it into a practitioner's life but they were bound to be concerned more and more with the management of animals and with what Mr. Gould referred to in his opening remarks as animal husbandry in its very widest aspect and a real understanding of the association between animal husbandry and health as well as between animal husbandry and disease.

With reference to Miss Uvarov's remarks, the question was rather outside Dr. Taylor's field but he did hear from workers on mastitis that there was a change in the pattern. More mastitis was found to be due to gram-negative organisms, but that was a detail into which the meeting should perhaps not go.

The methods they were using were of a blundering kind and they seemed to be methods of which they could not really be very proud. Trial and error seemed to be the only way. Antibiotics appeared and they were immediately seized on and used for everything. Only afterwards did they see the sort of thing that resulted and then they tried to put it right. It took quite a long time to determine what was happening and sometimes very much longer to put it right. Professor Baskett referred to the very great speed with which antibiotics came into use by animal husbandrymen as soon as they came out. He referred also to the time lag in the application of the revelations of investigation on the farms in the matter of putting things right. So it was that they went along by rushing hopefully into new procedures and slowly and painfully making artificial adjustments for the upset. It was a pleasing aspect that although we were sometimes slow in putting things to rights after we upset them, we usually succeeded in doing so.

Mr. Gould added that he had made it clear he was speaking from clinical impressions, and he was certain Miss Uvarov with her background would not speak without the statistical evidence for which she was asking. She agreed that the pattern of mastitis was changing. Some advertisements still made remarkably wide claims for penicillin in clinical mastitis. The position in respect of mastitis in his own practice, where penicillin had been widely used, was that for a period of about eight years the incidence of mastitis, with almost complete control of *agalactiae* infection, was very low. Then began a changed type of mastitis with marked constitutional symptoms in which penicillin had little or no effect in treatment. The cases built up to a much higher number with changes in types of teat liners and errors in milking methods. It was found necessary to go back to the old-fashioned type of teat liner in many dairies and it appeared to him that the old type of stretched liner was the best to use, some newer types being associated with a higher incidence of teat damage, less efficient milking and consequent mastitis.

As to whether the course of the disease was altering or whether resistant strains had arisen, possibly both factors applied; but it appeared more likely that infection with organisms normally resistant and not previously a problem was their main concern. There were types of staphylococcus which were very resistant to the ordinary run of antibiotics available.

Mr. Gould said he had reverted to using the sulphonamides and even acriflavine, giving 5 c.c. doses of the latter at 1 in 10,000 because it proved better in certain types of mastitis than antibiotics including penicillin.

The Chairman said it only remained for him to ask them to show their appreciation of Dr. Taylor's masterly paper. Although there had not been as much discussion as Dr. Taylor expected it had been extraordinarily interesting. The paper was one that made them think. They were greatly indebted also to Mr. Gould and Professor Baskett.

Sodium Transport and Its Role in the Ruminant Digestion

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IT is well known that wild ruminants make periodic journeys in search of salt. The reason for this, presumably, is that most of the foodstuffs they eat contain comparatively little sodium and a lot of potassium. The disparity between the sodium and potassium contents of the common farm foodstuffs was pointed out by Carlstrom (1950) when he addressed the National Veterinary Medical Association at Cardiff. Carlstrom's interest in this matter was aroused by his finding that the plasma values for potassium were low in many cases of acetonaemia in cattle. It has often been postulated, but never proved, that the high potassium content of grass might be concerned with the onset of the various metabolic disorders that occur in cattle at grass. Less thought has been given to the fact that if a plant has a high content of potassium it must also have a low content of sodium. This is well illustrated by various studies that have been made on the mineral composition of grass. Cruickshank (1926) showed that the potassium of herbage cut from permanent pastures at intervals throughout the season varied from 1.98 to 2.67 g. per cent. while sodium varied between 0.43 and 0.35 g. per cent. Recently Stewart & Holmes (1953) have studied the mineral composition of grass plots treated with all combinations of nitrogenous phosphatic and potassic manures over a period of three years. The figures they give show a very large variation and whenever potassic manures were applied the potassium content rose markedly and the sodium content fell. I have recalculated the values given by these authors so that they can be compared in equivalents of sodium and potassium which is preferable to comparisons in g. from a physiological point of view. The untreated plots had a narrow ratio compared with those studied by Cruickshank; the ratio of potassium to sodium being 0.82, 1.11 and 0.47 for the three successive years. Potassic manures alone, however, increased the ratio to 4.5, 10.2 and 19.9; potassic and phosphatic manuring gave ratios of 5.33, 7.20 and 13.6; and nitrogenous, potassic and phosphatic manuring gave ratios of 1.44, 2.48 and 8.59. The values found for nitrogenous manuring alone were within the range of the control plots: together nitrogen and phosphorous depressed the ratio, but phosphatic manuring alone increased it. The foodstuffs quoted by Carlstrom gave ratios that are of the order of 4 to 7, and he added the interesting observation that foodstuffs with a low content of potassium were associated with the evidence of acetonaemia. I am no clinician so I cannot comment on this statement but, as we have studied the absorption of sodium and potassium as well as other electrolytes from the rumen of sheep and are now extending these studies to the intestine, it is appropriate to give an account here of our work to see among other things what may be the result of changes in the sodium and potassium content of foodstuffs upon the availability of these elements to the animal.

Absorption from the rumen

A few studies made by Parthasarathy (1952) on the concentrations of sodium and potassium in the alimentary contents of sheep showed that in stall-fed animals the concentration of sodium was always considerably lower in the alimentary tract than in the blood, while potassium was always considerably greater in the alimentary tract than in the blood. Under these circumstances it appeared as though there would be little difficulty in the sheep absorbing potassium but that if it were to absorb sodium it could only do so against a concentration gradient.

The four ions that behave in a manner which cannot be explained on the basis of concentration gradients are bicarbonate, inorganic phosphate, chloride and sodium. Bicarbonate was found to pass into the rumen in considerable quantities which were related to but were less than the quantity of fatty acid absorbed. The concentration of bicarbonate in the rumen under these conditions could exceed that of the plasma. Chloride was absorbed against a concentration gradient unless the concentration in the rumen was less than 130 mg. per cent. in which event the concentration in the rumen increased. Sodium appeared to be absorbed from the normally filled rumen when a comparison of the venous blood leaving the rumen was made with the carotid blood even though the concentrations in the rumen were much lower than those of the plasma. Initially, however, we could not detect absorption from aqueous solutions in the rumen unless the concentration was higher than that in the blood (Parthasarathy & Phillipson, 1953). When discussing movements of ions across any membrane it must be remembered that when two solutions on either side of the membrane are in equilibrium, the movement of any ion across the membrane in one direction is balanced by movement of the same ion in the opposite direction so that no net change occurs in the concentration of this ion on either side of the membrane. When any ion is absorbed from the alimentary tract the movement from gut to blood exceeds that of the movement from blood to gut.

Detailed investigations of the absorption of chloride from the rumen were undertaken and the answer to the problem was found to lie in the existence of a potential difference across the rumen epithelium, the rumen contents being negative with respect to the blood by some 25 to 35 mV. Calculations of the total force, consisting of the concentration difference for

chloride in experiments in which different solutions were placed in the rumen and the measured potential difference, show that the net flux of chloride into or out of the rumen corresponded with the direction of the total force to which the chloride ions were exposed so that there is no need to assume "active" absorption of chloride (Dobson & Phillipson, 1954). In this instance the existence of a potential difference across the rumen epithelium means that there is a force over and above any force due to differences in concentration gradient which will tend to move negatively charged ions from gut to blood. Equilibrium therefore will be attained when the forces on either side of the rumen epithelium are equal. When this occurs there must be a greater concentration of chloride in the plasma than in the gut. This is expressed diagrammatically in Fig. 1. The diagonally hatched areas represent the

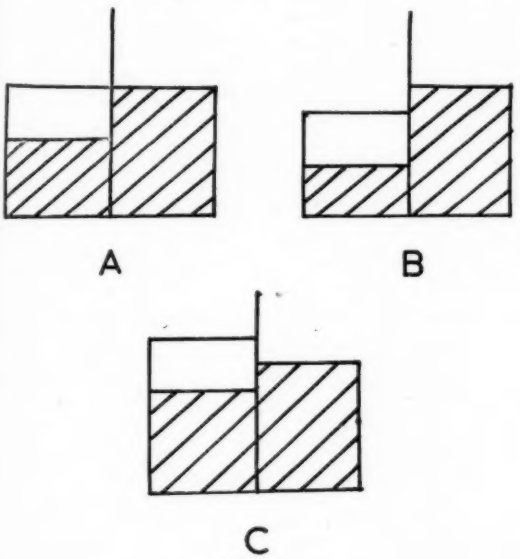

Fig. 1

Diagrammatic representation of the concentration of chloride in plasma—to the right of the mid-line; and in rumen contents—to the left of the mid-line; when (a) equilibrium is attained, (b) when the net flux is from plasma to rumen, and (c) when the net flux is from rumen to plasma. The unhatched area represents the force created by the potential difference.

force exerted by the concentrations present in the gut and blood while the clear area represents the force exerted by the potential difference across the membrane. The same considerations must presumably apply as far as all negatively charged ions are concerned in the rumen; with the fatty acid anions where there is a very large concentration gradient in favour of absorption the potential difference adds to this force. It is curious, therefore, that inorganic phosphate is not absorbed to any extent in the rumen even though the concentration is greatly in favour of absorption. The membrane is not impermeable to phosphorus for ^{32}P can cross it in either direction; the resistance to passage, however, may be considerable and, indeed, if the epithelium were not resistant to the passage of some anions it is hard to understand why the potential difference is present.

When we turn to positively charged ions such as sodium and potassium the position is reversed and the potential difference is an impedance to the transport from rumen to blood. If only two forces were concerned, the concentration gradient and the potential difference, then the concentration in the rumen would have to exceed that of the plasma by approximately three times before absorption could occur. Under normal conditions with stall-fed sheep this state of affairs is present for potassium but not for sodium. Looking back at the earlier experiments it was clear that although we only detected absorption of sodium when the concentration exceeded that of the plasma, yet for the differences in concentration present no absorption should even then have been found; in fact, a net flux of sodium into the rumen should have occurred. Further experiments were done, therefore, on very small sheep, using a more accurate method for estimating sodium and extending the period of observation. Under these circumstances there was not difficulty in finding absorption of sodium even against a concentration gradient, which proved conclusively that some other forces were present causing sodium to move into the blood against a concentration and potential gradient. This

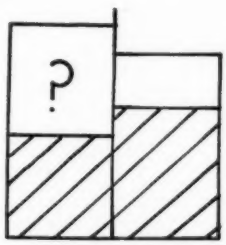

Fig. 2

Diagrammatic representation of the forces concerned with sodium absorption from the rumen. The area with the question mark represents the unknown force which causes "active" absorption.

is represented diagrammatically in Fig. 2. Here, as we are considering a positively charged ion, the potential force is on the other side and added to the plasma concentration gradient. The necessary and unknown force causing absorption of sodium is marked by a question mark. Under these circumstances sodium can be said to be "actively" absorbed and this is due presumably to activity by the rumen epithelium, Dobson (1955).

Sodium and chloride are the only two ions upon which detailed study has been made; whether the active uptake of sodium is responsible for the potential difference observed remains to be explained. If it is, then it implies a certain degree of resistance on the part of the epithelium to the passage of anions; a drop in potential difference such as occurs

with anoxia or after an injection of adrenaline, acetylcholine and histamine may mean either that absorption of sodium is depressed or that the resistance of the epithelium to the transfer of anions is reduced.

The Absorption of Potassium

The position with potassium is that the concentration in the rumen of stall-fed sheep is sufficiently high to overcome the potential difference so that absorption occurs. The quantities absorbed, however, are small compared with sodium. There is no evidence yet to suppose that any "active" mechanism is concerned. There is no information on the concentration of potassium in the rumen of sheep fed on foodstuffs with a low potassium content such as the control grass examined by Stewart & Holmes (1953), or of grass from pasture stimulated with nitrogenous fertilisers alone. Under these circumstances it may be much lower than the values at present available, and if the concentration falls below three times the plasma concentration, namely 12 m.equiv. per l. (approximately 50 mg. per 100 ml. of rumen liquor), then the net flux of potassium should be from plasma to rumen and presumably the animal should deplete itself slowly of potassium; this assumes that the potential difference remains in the region of 30 mV. Reference to Fig. 2 can be made to appreciate what may happen to a positively charged ion if the force marked by a question marked is removed.

The position with bicarbonate or carbon dioxide is interesting; in acute experiments we have found that it replaces a considerable part of the fatty acid anion absorbed from the rumen and that it can pass into the solution in the rumen against a concentration gradient and also against a potential difference although this was not measured in the experiments in question (Masson & Phillipson, 1951). The movement of bicarbonate or carbon dioxide in the opposite direction to the fatty acid anion is necessary to maintain ionic equilibrium in the solution in the rumen but for this to occur at the speed with which it does, particularly against opposing forces, strongly suggests an active mechanism on the part of the rumen epithelium. It is also possible that the high concentration of inorganic phosphate in the rumen which is maintained is due in part to the active participation of the rumen epithelium, causing a flux from blood to rumen that is equal or nearly equal to that going in the opposite direction.

The experiments on which these hypotheses are based were all done on sheep under pentobarbital anaesthesia in which the oesophagus was ligated so that no saliva entered the rumen.

Dobson (1955) calculates that the work done by rumen epithelium in transporting sodium from the rumen to the plasma is not less than 0.2 μW. per mg. dry weight of the tissue and that at times this force exceeds 80 mV. In this respect the rumen epithelium is a highly active tissue. The reason why we think this is of interest is that the animal has to work hard to obtain sodium and also to reabsorb much of the sodium which pours into the rumen in the saliva in a similar manner to the kidney which has to work hard to reabsorb sodium to maintain the high concentration of sodium in the plasma. The high potassium and low sodium content of the tissues also suggests a similar process by which sodium is forced into the plasma. There is at present no reason to suppose there is an active mechanism concerned with the uptake of potassium from the gut, but with regard to the kidney and the tissues it would be unwise to make any such assumption. If the sodium "pump" fails in the alimentary epithelium, or in the kidney tubules, or in the cells themselves, profound changes in the electrolytic balance of the animal may occur, and such a condition is seen after removal of the adrenal glands. The corticosteroids are sometimes divided into mineral corticoids and glycocorticoids. This division appears to me at present to be artificial rather than true. My colleague, J. V. Evans, is studying the effects of desoxycorticosterone and of cortisone on the sodium and potassium balance of sheep and finds that although their action in this respect is different, they both affect the balance. It does appear probable, however, that anything which interferes with the active uptake of sodium from the gut will lead to a failure to absorb the sodium introduced into the alimentary tract in the secretions and even to allow sodium to leak into the gut from the blood on account of the high concentration gradient between plasma and the gut contents. It is well known that high salt intakes are needed in the rat and dog to maintain adrenalectomised animals; this could be because active uptake of sodium in the intestines is lost and absorption cannot occur until the gut concentration exceeds the plasma concentration. Absorption of sodium in the ileum of the dog against a concentration gradient has been recognised for a long time. Blaxter & Woods (1953) have recently shown that scouring calves are in a negative balance for both sodium and potassium. Leakage of sodium into the gut presumably must be followed by a loss of chloride, probably bicarbonate, and water and if iso-osmotic conditions are to be maintained under these circumstances it is easy to understand how scouring leads to dehydration. Any agent present or produced in the gut that damages the intestinal mucosa presumably may impair the ability of the mucosa to absorb sodium, and if the sodium pump from gut to blood stops there is nothing to prevent a large sodium flux occurring from the blood into the gut.

It is common to assume under conditions in which the loss of electrolytes and water occurs that the origin of this condition is in the adrenal cortex. This is certainly not always logical for it can equally well mean that the target organ, wherever it is located—the kidney tubule, the tissue cell, or the alimentary mucosa—is damaged and therefore is incapable of responding to adrenal corticoids. It is certainly wise where there is rapid loss of condition and falling away of an animal—as, indeed, is described by Carlstrom (1950) for cattle with acetonaemia—to look for loss of electrolytes and water and to replace them.

In parentheses, it is necessary to add that the picture as I have emphasised it is certainly an oversimplification. I have done this deliberately in order to stress the physiological and pathological import-

ance of the active transport of sodium whenever it is found and the probable results that may occur from interference with the mechanism. In addition, it is important to realise that the same conditions apply to potassium except that with this ion, as far as is known at present, there is no active force concerned with its absorption.

Summary

The rumen epithelium is a selective membrane. Sodium is actively absorbed but potassium—as far as is known—is passively absorbed and in less quantity than sodium. A potential difference of the order of 25 to 35 mV. exists between the rumen and the blood, the blood being positive to the rumen. This means that chloride can pass to the blood from the rumen against a concentration gradient. The significance of this potential in relation to the behaviour of other charged ions is discussed.

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THE SPEAKER'S INTRODUCTION

The Chairman (Mr. Alex Thomson) said that he wished to apologise on behalf of Mr. Hart, who was to have been Chairman but was unavoidably unable to be present. It was a pleasant duty to welcome those present and to introduce to them Dr. Phillipson, who in fact really required no introduction to most of the audience. The subject was a necessary follow-up of some of the things they had been discussing that morning. Dr. Phillipson had been foremost in many investigations on the subject and they would welcome his elaboration of any points in the paper.

Dr. Phillipson: "I must apologise to the Provisional Committee because I have not really done what I was asked to do. I was asked to give a paper on recent advances in ruminant digestion, and I have in fact selected one small part of the subject and discussed it in some detail. The reason for that is that a paper on advances in ruminant digestion would have been somewhat long.

"First, I would put before you some figures which I believe crystallise the fundamental problems we are dealing with:

	m. eqiv/l.		
	Rumen Contents	*Plasma*	*Red Blood Cells*
Na	60-88	140-150	34-80
K	25-45	3.8-4.4	89-24

"These figures give the concentrations for sodium and potassium found in the rumen contents, the plasma and the red blood cells of sheep. The problem of how the difference between the concentrations of these elements inside and outside the red blood cells is maintained is a very old one and the same problem exists when we compare the plasma and tissue cells.

"The relations between the rumen contents and the plasma is a new problem and the same problem presents itself for the remainder of the alimentary tract and may be the same in other species than the ruminant. It has been known for a long time that sodium is absorbed from the ileum of the dog against a concentration gradient. It is with this aspect of the problem that my paper is concerned. This problem is interesting because the adrenal corticosteroids are known to have a profound effect on the sodium and potassium balance of the animal and because there is evidence to show that the quantities of sodium entering and being absorbed from the alimentary tract in ruminants are very large.

"The concentration of sodium in the saliva is similar to that of the plasma, yet the concentrations in the rumen are much lower; this is due to the fact that foodstuffs do not contain much sodium and because sodium is absorbed from the rumen.

"The absorptive capacity of the rumen can be determined in anaesthetised sheep by introducing known solutions into the empty organ and determining the loss over a period of time. An estimate can also be made by comparing the sodium content of the arterial blood and of the venous blood leaving the rumen. We know the output of sodium in the faeces of sheep fed on standard rations and it is small; from this and other data it is possible to make an assessment of the probable quantities of sodium absorbed from the rumen and intestines of sheep and this is shown in diagrammatic form on the slide. The problem we are concerned with is to understand how sodium is absorbed from the rumen. The nature of this process is important to the animal because, if anything stops it, it is clear that the animal will lose sodium in the faeces and become dehydrated.

"The active uptake of sodium from the rumen and intestines may be related to the adrenal cortex, but we have no proof of this.

"The existence of a potential difference between the rumen contents and the blood, as described in the paper, is useful in explaining the absorption of anions from the rumen. Sodium, however, moves against a potential and a concentration gradient, and for this to happen the rumen epithelium must be performing work.

"The question whether the active uptake of sodium is responsible for the potential difference remains to be seen; if we draw an analogy from frogs' skin, this is likely to be true. In parenthesis I must add that although the work I have described concerns the rumen, the ultimate object is to understand the electrolytic balance of the whole animal."

The Opener

The Chairman said that in asking Dr. Alexander to open the discussion he would say that it was an interesting facet of development that there were now farm colleges entering the field in such large measure. Those who remembered the *Criteria Medica* could hardly imagine the large part the farm college occupied in their activities.

Dr. F. Alexander: "I should like to take this opportunity of thanking Dr. Phillipson for his interesting paper and for the work he has done in the difficult field of rumen physiology. One aspect of his type of work which is not generally appreciated, but which will, I know, be fully appreciated by an audience such as this, is the physical difficulty of carrying out experimental work on ruminants: the difficulty of anaesthesia, difficulties due to their peculiar anatomy, and many others. A physiologist working with experimental animals such as sheep and goats has problems which a person working on small laboratory animals never encounters. In the course of his work Dr. Phillipson has successfully overcome many of these problems.

"The increasing importance of diseases of metabolism and the need for the food-producing animals to be fed in such a way as to give a maximum return makes it essential for all of us to try to understand as much as is known about the rather specialised physiology of the ruminant.

"The rumen is very often regarded as a simple fermentation vat whereas its functions are much more complex. It is now rather more than a decade since Dr. Phillipson, in collaboration with Sir Joseph Barcroft and others, published work showing that the lower fatty acids which are the principal products of carbohydrate fermentation in the rumen were absorbed directly through the rumen wall.

"This concept of the direct absorption of products of digestion through the wall of an organ lined with squamous epithelium was not at first appreciated. Although earlier work had shown that drugs such as strychnine could be absorbed through the rumen wall these experiments were

regarded as rather artificial. However, Dr. Phillipson has extended this work to include a study of the absorption of various inorganic ions by the rumen, and it is with this that his paper is concerned.

"My contribution to the discussion, I am afraid, will have to consist of seeking further enlightenment from Dr. Phillipson. I should like first to ask him whether there is a potential difference between the gut contents and the blood of other parts of the alimentary tract, and also whether the main site of the Na absorption, the kidney tubule, shows this difference. It appears from the paper that this potential difference is much smaller when the rumen wall is deprived of oxygen and also after the injection of adrenaline, acetyl choline or histamine. I should like to suggest that these drugs were affecting the potential difference in the same way as the lack of oxygen, namely by decreasing the blood flow through the rumen wall and hence the supply of oxygen. I should also like to ask whether the absorption of sodium is affected by oxygen lack or by these drugs mentioned.

"In an earlier paper Dr. Phillipson and Parthasarathy found that the application of mercuric chloride to the rumen wall inhibited the absorption of acetate and chloride ions, but not the absorption of potassium or sodium. This could be regarded as evidence that these latter ions were not absorbed by 'an active process'; an 'active process' meaning a process involving enzymes and not simply physical forces. Does mercuric chloride affect the potential difference between rumen contents and plasma?

"With reference to certain metabolic disorders of cattle being caused by an excess of potassium in the blood perhaps the best example is that of 'wheat poisoning,' a disease occurring in the Southern States of America. Cattle fattened on sprouted wheat show a hyperexcitability which is considered to be caused by an increase in the ratio of potassium/calcium in the plasma. It is claimed to have been successfully treated by injections of calcium borogluconate with or without magnesium.

"It seems possible that not only the classical milk fever will respond to injections of calcium and it may be that some atypical cases of milk fever which respond to calcium therapy are in fact cases of hyperpotassoemia.

"The ruminant deals with calcium in a different manner from many other animals in that calcium is excreted by all parts of the gut, whereas in man, for example, it is excreted only in the urine. It will be interesting to hear whether Dr. Phillipson has any observations to make on the absorption of calcium from the rumen.

"Evidence is accumulating that ruminants treat inorganic ions in a different fashion from many other species. I have wondered whether, for example, the use of sodium chloride as a purge in cattle is not evidence of this difference, or does it simply mean that if a proportionate dose were given to a dog it would vomit and therefore not show any cathartic effect?

"From the experiments of Garton it appears that the omasum is largely concerned with the absorption of water. Does the rumen also absorb appreciable amounts of water?

"The important function of sodium is, of course, in maintaining the correct pattern of water distribution by means of its osmotic pressure effect. The clinical importance of this might be illustrated by an example: I understand that when racehorses are imported into the West Indies from a country such as this, they sweat a great deal and, as the sweat of the horses contains a large amount of sodium chloride, they lose a lot of sodium. After a time these animals become incapable of sweating; and if, after this happens, they are still worked, they lose condition and deteriorate very rapidly. A complete cure is said to be effected by the administration of sodium chloride.

"I should like now to make a few remarks about the hormones of the adrenal cortex. Dr. Phillipson suggests that to divide them into two groups, those affecting carbohydrate metabolism and those affecting mineral metabolism, is artificial. Whilst agreeing that most classifications are artificial and that the hormones of the adrenal cortex have actions in common, I should like to emphasise that there are marked differences between them. For example, the recently isolated aldosterone is at least 100 times more potent in restoring the electrolyte balance of rats deprived of their adrenal glands when compared with desoxycorticosterone. This latter substance DOCA is a synthetic hormone of relatively low cost, and, because of this, used in experiments and therapy. DOCA has the disadvantage of causing excessive retention of electrolytes and water which aldosterone does not. Moreover, when using DOCA the diet must be carefully regulated to avoid feeding too much sodium and water.

"Normally the kidney tubule is the site of recovery of sodium ions back to the body, a recovery which is most efficient. If you are on a sodium-free diet you can still live because of this efficient recovery process. The potassium in excess of requirements is excreted in the urine. When the hormones of the adrenal cortex are no longer there, and in particular the hormones which influence the electrolyte metabolism, the renal tubules can no longer distinguish sodium from potassium and so considerable amounts of sodium are lost in the urine.

"Cortisone and hydro-cortisone usually are considered as glyco-cortocoids. They have also an interesting effect on mineral metabolism. These hormones appear to act by correcting any deviation from normal either by increasing the retention of sodium or increasing its excretion. Since ACTH causes the release of cortisone along with other hormones of the adrenal cortex and, as I understand, many cases of acetonaemia respond to ACTH, it may be that the correction of an electrolyte imbalance rather than a carbohydrate disturbance is responsible for the cure. This hypothesis would support the suggestions of Carlstron and those of Dr. Phillipson. It is unfortunate that there is no incontrovertible evidence to support the use of ACTH in ketosis mainly because proper therapeutic trials have not been conducted. This is largely due to the technical difficulty of carrying out such trials. However, I believe this Association is making an effort to overcome some of these problems, for which the people concerned will deserve our gratitude.

"I should like again to thank Dr. Phillipson for the work he has done and the Council of the British Veterinary Association for giving me the privilege of opening this discussion."

The General Discussion

Mr. M. Crawford (Weybridge) said that he had not intended to speak at all, knowing nothing about ruminant digestion, but he could not less pass some remarks of Dr. Alexander about dry sweating in horses. It had been said that dry sweating occurred in the West Indies, and it was explained as a simple and straightforward sodium deficiency. The condition did occur in the West Indies, but it was very much more prevalent in other places such as Calcutta, Penang, Colombo and Rangoon. It should not be taken as proved that it is really a sodium deficiency.

Mr. Crawford thought the evidence rested on a paper by an American worker, Gilyard, R. T. (1944), who saw some cases and treated one of them with sodium injections. It was not safe to take that as proof. If the condition rested on sodium deficiency, it was curious how frequently it occurred in Colombo, where all horses were provided with rock salt.

Also, the argument about loss of sodium through sweating did not seem right. A horse probably lost as much potassium as sodium through sweating. The sweating of a horse was an entirely different mechanism from sweating in man, and it was not safe to argue by analogy from man to the horse. Again, simple sodium deficiency did not seem to answer the question.

In Colombo there was a very high incidence of dry sweating in horses imported from Ireland, England and Australia; but there were just as many Arab horses there imported from the Persian Gulf, which were fed in the same way and housed in the same stables, and yet Mr. Crawford had never seen one which was a dry sweater.

The Chairman said that if there were no further speakers it was an indication of the completeness of the answers Dr. Phillipson had given or else it was due to shyness. He would ask Dr. Phillipson to reply to the points that had been made, and afterwards an opportunity would be given to Dr. Alexander to reply to Mr. Crawford.

The Reply

Dr. Phillipson, in reply, thanked Dr. Alexander for his remarks. Concerning methods, it was always necessary to learn new methods, and Dr. Phillipson was made acutely aware the previous day that they should overhaul their methods in regard to anaesthesia. There were many new methods available, and these might be better than the methods adopted. It was always a problem in physiological work to know how far work on an anaesthetised animal could be applied to an animal in the field.

Dr. Alexander had raised many points. First there was the question of whether there was a potential difference in the gut. A colleague of Dr. Phillipson's, Dobson, had recently turned the method to some use in the cecum of sheep, and there was a potential difference between the blood and the caecal contents, which was of the same magnitude in the rumen.

With regard to the kidney, he did not know whether anyone had attempted to measure the potential difference between the inside of the kidney tubule and the blood. It would probably be an extremely difficult thing to do. Wherever there was the phenomenon of an active transport of sodium—and Dr. Phillipson agreed entirely with Dr. Alexander's definition of an active process as opposed to a passive one—it seemed probable that the same mechanism was at work. The importance of knowing the potential difference across any membrane under investigation was that without knowing it and the concentration difference there was no true criterion by which to distinguish "active" from "passive" transport of an ion.

For the immediate future it was best to persevere with a preparation which was easier to deal with than the kidney tubule, and try to do detailed work on it before dealing with a much more difficult preparation.

The question of the oxygen lack was interesting. If in an acute experiment the potential of the rumen was measured and the animal was then made to breathe nitrogen for a short while, the potential difference immediately decreased. It did seem probable that Dr. Alexander's explanation of the effects of the drugs, adrenaline, acetyl choline and histamine, might be due to oxygen lack. Most attention had been given to the effect of adrenaline; this had a diphasic effect on blood flow. Immediately following injection the blood decreased, but the decrease was followed by a period of increased flow before it returned to its resting value. The potential invariably decreased when the blood flow decreased and could well be due to a decrease in the oxygen supply to the epithelium; the depression of potential, however, persisted into the second phase and only gradually returned to its resting value.

The question whether the source of sodium was depressed during an adrenaline injection was one Dr. Phillipson had not looked into. Adrenaline inhibited the active uptake of sodium in frog skin. The experimental arrangements necessary to measure blood flow made it difficult to determine how much sodium was going out of the rumen at the same time. He had not investigated the effect of mercuric chloride.

The question of water absorption was interesting. Again referring to frog skin, whenever there was an active uptake of sodium, water followed sodium. To keep a constant volume of water in the rumen of a sheep under experimental conditions it was necessary to use a solution that had a slightly higher osmotic pressure than that of the plasma.

Dr. Phillipson agreed with the need for classification, but it was necessary to point out that classifications were occasionally somewhat artificial. Electroaldersterone had only recently been discovered. He had written to the chemist who had discovered it to see whether some could be obtained, but at that time his total stock was about 5 mg. and it was very much in demand.

One of the difficulties in carrying out experiments in which such materials were used was the problem of costs. These materials were expensive, and to get really reliable results it was necessary to do many experiments, so the total expenditure was considerable. DOCA and cortisone were available in fair quantities, and they both affected the sodium output of sheep, but in the opposite directions.

The point raised by Mr. Crawford was one Dr. Alexander might wish to cover.

Dr. Alexander said he felt he must accept the very doubtful privilege of "opening" again. He would point out that in making the observations Mr. Crawford referred to he had said he understood them to be correct. He had probably been quoting from the paper Mr. Crawford had mentioned, not having been to the West Indies himself. The published evidence had appeared good and dependable.

The Chairman said that it only remained for him to express the thanks of the meeting to Dr. Phillipson and Dr. Alexander for making relatively clear at least one aspect of digestion, which was a fascinating if extremely complicated subject.

Transport of Animals and Problems Arising—Air Transport

BY

R. C. G. HANCOCK

Ecchinswell, Newbury, Berks

Introduction

THERE is a paradox in the fact that the important and interesting things on which successful air transport of living creatures other than men depends take place chiefly on the ground. For the difference between ease and disease, between life and death even, can only be based upon wide ecological experience, and patient study of the habits and essential requirements of any species destined shortly to be hurled through space at many hundreds of miles an hour.

To give a few simple examples. Experience has established that, at sea level, every gallon of water in a tank can support about 1 inch of fish. But take that tank up to 20,000 feet and you must alter your rule to read 2 gallons to every inch of fish. Because oxygen in solution varies with atmospheric pressure, thousands of fish in transit by air have been lost through ignorance of this simple physical law appertaining to gases in solution. The "boffin" on the ground now provides containers into which oxygen can be pumped to create conditions for the fish at altitudes superior to those at ground level. The result is that tanks containing thousands of valuable tropical fish can now come from South America to this country with scarcely a casualty.

The greyhound traffic by air between Ireland and England was nearly stifled in its infancy by the frequent deaths *en route* of valuable animals from internal haemorrhages. The tale has so frequently been repeated by journalists that it is no doubt familiar to many of you. Briefly, the trouble ended as the result of an intuitive hunch as I stood in a Dakota at Northolt among a bunch of freshly arrived immigrants. There was a row of travelling boxes side by side, with nowhere for the inmates to see out. "Just like a row of starting traps," I thought. Fill that row of traps with greyhounds. Immediately, associative mechanism will suggest that a race is imminent. The engines start up suggesting the approach of the hare. The seconds pass by, yet there is not the accustomed release. So, their barking drowned by the roar of the engines, the frustrated creatures pass from tense excitement to a pathological frenzy, with apoplexy imminent.

The inquisitive in such matters tell me that the first animal to travel by air was a sheep. So, not only does this gentle animal stand as a pioneer of animals that fly, but as a forerunner of that gallant breed of men—the test pilots. The fact that the sheep was supported during his or her flight, not by wings but by hot air, may also have some esoteric significance at the present day.

The Dutch claim to have been the first to carry an animal as commercial freight, when K.L.M. in 1923 transported a bull to an agricultural show. But it was not until the advent of cargo holds that could be maintained at a steady temperature in the passage of the aircraft over continents, and later also at an atmospheric pressure approximating to that at ground level—by pressurisation—that the transport of animals by air could reach its present great dimensions, numerically as great, so far as London Airport is concerned, as the human traffic. What the figures for this year are likely to be, it is hard to guess. The R.S.P.C.A. hospice at that airport only handles a proportion of the animal travellers to and from these islands, but there passed through the hospice during the month of April this year no

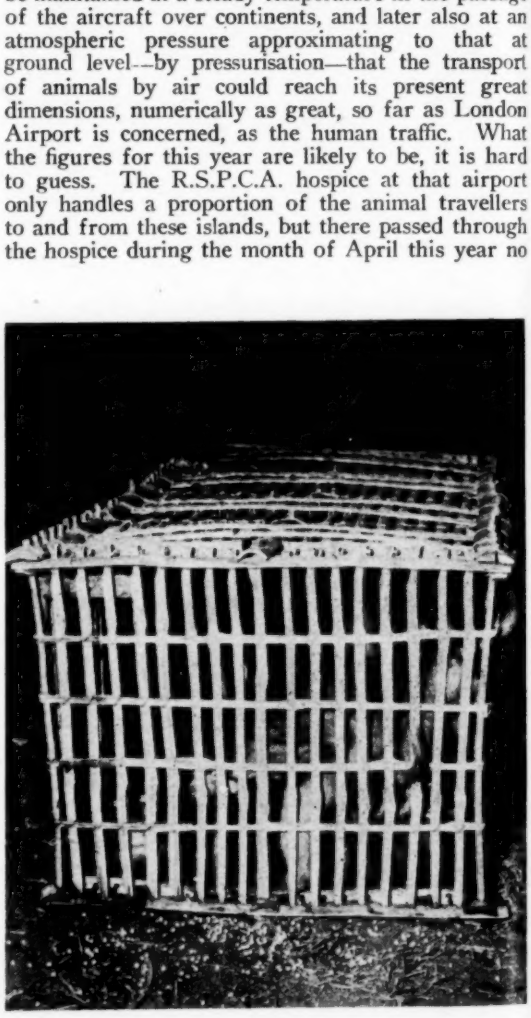


FIG. 1.—"The weird bamboo concoctions of the Indian carpenter."

less than 113,000 living creatures, double the previous monthly figures.

The R.S.P.C.A. Hospice

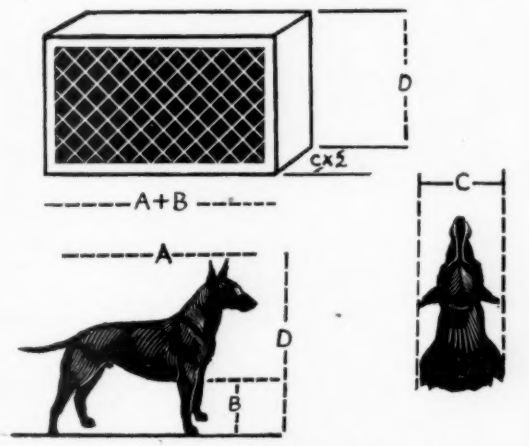
The genesis of this hospice is not without interest. Few of us are historically curious enough to realise how often the R.S.P.C.A. has been the god that set the financial machinery in motion to implement the dreams of the veterinarian. Let me remind you that this society found the money for the parliamentary recognition and charter of the profession sought for by the R.C.V.S. in the forties of last century. In the forties of this they once again implemented the dreams of a member of the veterinary profession by finding a large sum of money to erect the prototype animal hospice now in operation for its third year at London Airport. I emphasise the word prototype, for in 1947 when I began to interest myself in the problem, there was not in the whole world a specialised building or organisation, nor is there today for that matter—other than the R.S.P.C.A. hospice at London Airport—devoted to the welfare of animal air travellers. The fount from which the enterprise sprang was the increase in volume of complaints, most of them from the transport staff of the air corporations, that reached our Headquarters suggesting that the R.S.P.C.A. ought to do something about the shocking way in which animal traffic was being handled. Whether it was the pain of an over-distended bladder in a house-trained dog that could not leave its plane for a run round because of quarantine regulations, or the deaths of half a consignment of tropical birds numbering 1,000 or more, enquiry showed ignorance of natural history to lie at the basis of all these unhappy events that threatened to bring air corporations into court on cruelty charges.

Conferences with the transport officials concerned showed there was anxiety to learn. In fact, they *must* learn, was the British cry, or they would never gain a fair share of the traffic from the Dutch and Americans, who had got there first. Education was obviously the answer. There must be a corps of animal handlers expert in the feeding and handling, not only of domestic pets, but of exotic species, ranging from the elephant and lion, down to the humble mollusc, to accompany livestock on the freight planes. I found that on arrival in London Airport the care of the animal passenger was left largely to a pet shop proprietor, and the animals were being held in huts of the Nissen type. Quarantine was more honoured in the breach. One of the earliest requirements arising from our meetings and discussions was this urgent need for an airport hospice, to be made available to all air corporations using the airport where all animals could be housed and fed. Eventually the Council of the R.S.P.C.A. determined that they would build, staff and operate such a building.

Some Difficulties

I will not attempt to weary you with the details of the long and dreary struggle that ensued from 1948 to the end of 1952 to get the place built. The architects were prompt, and reproduced my rough sketches with the docility of those who know little of the primary requirements of the strange species to be housed. Of the Ministries—of Air, Civil Aviation, Agriculture, the Treasury, Customs and Excise—I will say little, and so avoid pack-drill! On the question of site rental on the aerodrome, agreed under the circumstances at a nominal shilling a year, the Treasury sat for six months, thereby delaying building operations by that period. The Ministry of Agriculture alone provided the outlines of their quarantine requirements in the kennels promptly. Customs had unequivocal views as to the locks, bolts and bars requisite to hold creatures not yet cleared by them. By the time we had surmounted all these obstacles, two years had passed and the original estimate of £13,000 for construction had risen to £20,000.

We opened to traffic in January, 1953. Our only trained and knowledgeable staff in regard to wild animals was the resident manager. How many workers, what stores of food, what equipment we needed—time was to teach us. It is astonishing how, by working day and night, four or five devoted people can feed, clean and tend to the minor accidents of a plane-load of 4,000 monkeys *en route* to the U.S.A. from India. For some time now only minor accidents have occurred, and major surgery is rarely called for. But it took a trip to India and Singapore to get the importers there, growing rich on the kidneys of monkeys, to stop the awful losses and suffering they were imposing on their victims. It was common to find pregnant



Measurements of Dog deciding size of Travel Crate

A = Length of Dog from nose to root of tail
B = Height from ground to elbow joint
} A + B = Length of Crate.
C = Width across shoulders:—double this for depth of crate back to front.
D = Height of dog in standing position = height of crate.

These sizes should not be exceeded for air travel by more than a few inches. For ship, train or road vehicle they can be materially increased, both for dogs and cats.

FIG. 2.

females, parturient prematurely or full time, in cages also occupied by males, whose preoccupation during and after the confinement can be summarised in one word—rape.

The dysenteries that early on made so many monkeys ill are no longer seen. The simple insistence that the monkeys are to be fed on what they had in the Far East, during travel and at the hospice, has removed that blot. I can recommend as penance the cleaning out of a cage containing a number of monkeys with diarrhoea. I can commend the courage of our staff who have caught this dysentery in the early days, not to mention other diseases, such as psittacosis, and who yet return undaunted to their labours.

Problems of Design

The original picture that rose in my untutored mind in regard to the ground plan of the hospice, was to build it round a large hangar-like central space into which lorries could be driven and their live cargoes locked in securely. It seemed a harmless fancy to make this central hall look like the hangar, semi-circular in section, common in the early days of aerodromes. Along one side I ranged my cat and dog kennels, half of them to quarantine requirements. On the opposite flank I put my stabling. I designed extra large stable doors capable of allowing the passage of pregnant elephants laterally, and of giraffes vertically! I often wonder whether in my lifetime I shall see my prevision in regard to the giraffe justified. So far, no aeroplane exists capable of containing that long neck!

Looking at the front entrance to the hangar, on either side are, to the left, the offices, surgery and pharmacy. To the right the food store and kitchen balance the front elevation. I might mention, as evidence of thoroughness, that it took a long time to find out what was the drawbar pull of an elephant against its tethering ring in the floor, as well as to

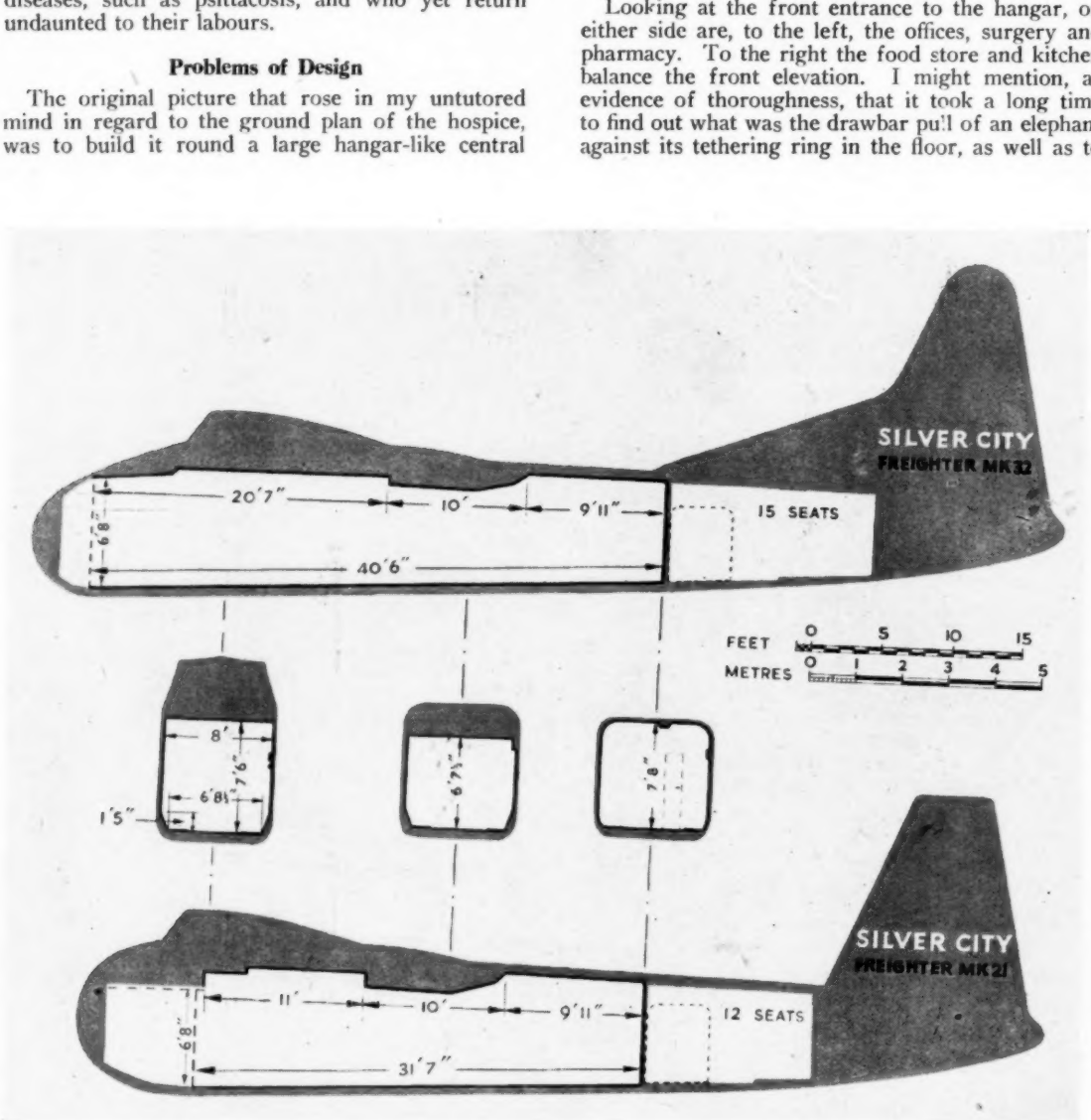


FIG. 3.—Bristol Freighter.

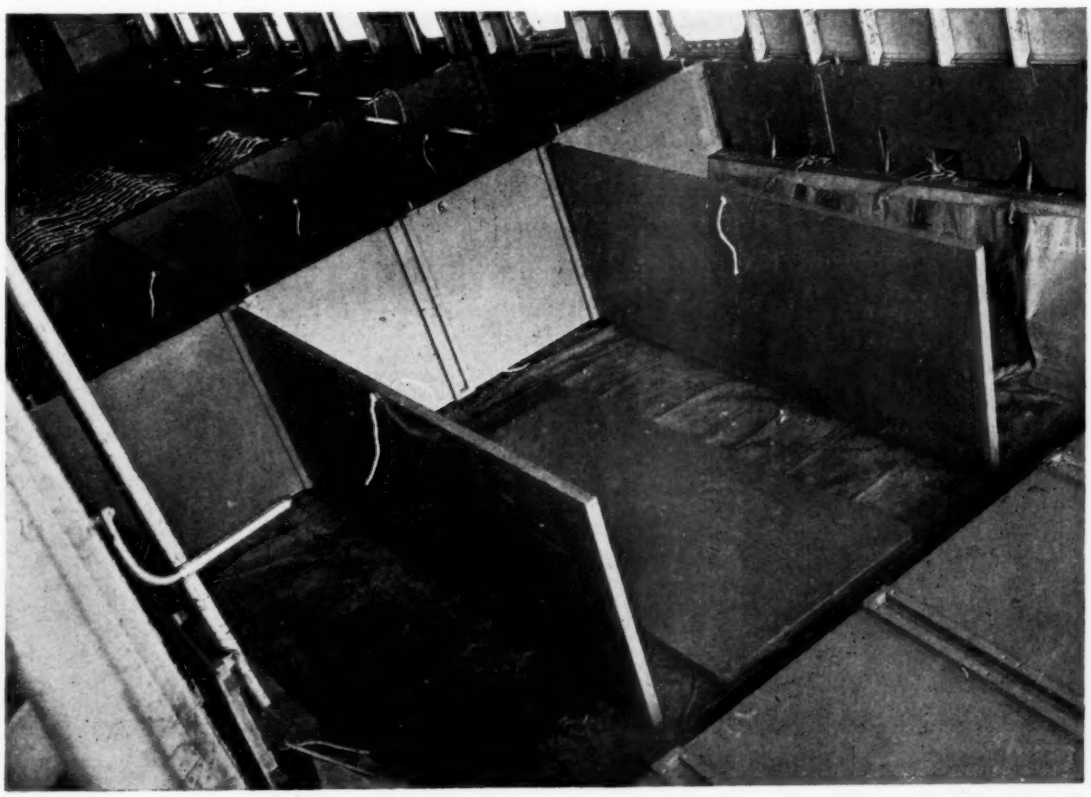
Drawings by courtesy of Silver City Airways

get a specification of the steel to be used in forging this item of elephant equipment!

By good luck the dimensions of the building have so far been adequate for the greatest demands, and I see no need for some years to contemplate enlargement. Nor have the staff requested any major alterations for the greater comfort of their charges or the more expeditious handling of the cargoes that arrive. My own view is that electric heating is too expensive to generate the tropical temperatures we have to create for days at a time, especially during the winter.

The varieties of foodstuffs that have to be held ready in the larders is staggering. Few are the grains we do not seem to need at one time or another, particularly for the birds, for 100,000 covering a score of species in a month is not an unusual tally. Penguins and seals are not popular week-end callers, for they need fresh fish fed by hand daily—in the case of a seal 10 lb. a day. Every 20 lb. of lion needs a pound of raw flesh at each meal. Cold storage is an immense help here.

The containers that bring the animals vary from the weird bamboo concoctions of the Indian carpenter, to elaborate hardwood crates for the larger cats and bears. For the latter, sheet metal linings meticulously fitted to prevent prising claws from initiating damage leading to escape are necessary. The laying down of correct and humane dimensions is far more exacting than in the case of land transport. These containers have to be non-returnable, and therefore as cheap as possible, for an aeroplane load of empty cages flown back to India for re-use at 15s. a kilogram would cost £3,000 in freight charges. So far as containers for dogs and other small mammals go, I specify that the ceiling must be an inch or two higher than the dog standing erect, and the length must also clear forepaws and buttock when sitting upright. The width that allows for turning round, and yet is not too great to prevent the animal bracing himself in bumpy conditions has been set at twice the width across the shoulders. This standard set of dimensions has been adopted universally by carrying agents, and has proved itself as a humane formula. Monkeys are conveyed in wooden cages covered with wire netting. Twelve Rhesus monkeys, of 4 lb. average weight each, or nine of 7 lb., go in a cage measuring 3 ft. by 1½ ft. by 1½ ft. Some game birds need a false ceiling of hessian or canvas, or they will injure themselves on



Photo, by courtesy of Silver City Airways

FIG. 4.—PIG-PENS. Showing method of assembly and netting which is used to cover and secure. Depending on the size of the animals the average load is estimated at 28 pigs per each Bristol Freighter.

the roof. For saltatory reasons barrels containing certain frogs require a fabric cover or they will suffer a similar fate. The metal linings necessary for bears are needed also for most rodents. Poisonous reptiles need little or no attention fortunately. But a crate did burst open recently, and fill me with recrimination to such effect that the hospice now holds a stock of all available anti-venins, and a suction pump for local first-aid at the site of the bite!

The Aircraft

Of all the aircraft that are used for animal freight, the Avro York and the Bristol Freighter seem the most adaptable, though it cannot be long before special fast turbo-prop pressurised aircraft, easy to load and unload, will be designed specially for live animal freight. Meanwhile, the York, with its high wing above the fuselage, its tailwheel undercarriage, its large door, whose sill is only 3 ft. from the ground, has been a great factor, enabling B.O.A.C. to provide safe and reasonable flight conditions for animals. For elephants, horses and farm livestock, floors have to be covered with timber or sheet metal to distribute the great weights over the ribs of the aircraft. The most prosaic and uneventful flights seem to be the lot of the large and small ruminants. They travel quietly and well. Even calves are now coming into the picture, and reach all parts of Africa from Great Britain with nothing more than food and drink *via* a dummy teat available *ad libitum*. Large numbers of cattle, sheep and pigs leave this country to go to purchasers in all parts of Europe.

For this continental traffic, the Bristol Freighter is the choice of the airline that carries most of the traffic. The surprising amount of space available in the modern aircraft is well shown in the photo of the interior of a Bristol Freighter with pigsties installed. Like the cattle pens and horse boxes, all these fittings are easily removable. The average number of large pigs conveyed in a single flight is 28. The load is 4,500 kilos or about 4½ tons. The cost, say, from Canterbury to Paris would be between £80 and £90.

I remember going to London Airport in the early days to see the "loose box" erected in a Dakota that I was asked to approve for a racehorse going to Singapore. It turned out to be a batten framework covered in wire netting. One kick would have collapsed the lot, and the second kick would have been through the skin of the aircraft. I can find only one serious incident, that of a racehorse going mad as a result of an attack of hysteria on the plane, of his stable pal, a greyhound. The aircraft was, by all accounts, lucky to land safely. Laymen are apt to underestimate the destructive powers of a large animal gone berserk.

The R.A.V.C. seems to have no archives on the transport of mules, although many were airborne in the Burma campaign, and many were carried without incident "over the hump" to China. This is as might be expected with an animal of such lung capacity, and although some journeys involved altitudes of 16,000 to 20,000 ft. they caused no distress. The standings in the planes were limited by bamboo poles and two pairs stood facing each other. Chloral hydrate was given half an hour before flight to unruly subjects. Bullocks travelling by air in this same campaign were placed usually three abreast, six in all.

On the question of doping animals, particularly dogs and cats prior to flight, I am against it. The varying reaction of each individual makes it a tricky business, and premature partial recovery of consciousness may cause more suffering than less. It would need a veterinarian on board to keep the subject in perpetual euphory on a long flight. An experienced animal attendant with a voice that carries reassurance is the best insurance against mental stress and frenzy.

Ailments during Flight

A whole paper could be devoted to the ailments induced by or ancillary to the flight of animals. I have mentioned dysentery in monkeys and psittacosis of the parrot family. Pneumonia was the cause of our first death at the hospice—in an ostrich. Starvation and thirst killed thousands of the small Indian finches that are imported into these islands and all over Europe, until, with the help of experts, I re-designed the cages, and sent specimens to India to the principal exporters, threatening to stop the traffic altogether unless they designed their cages to our pattern. B.O.A.C., as ever, were most cooperative on this mission. A great diminution in losses followed. Female monkeys now travel in separate cages from males. We no longer get large numbers with scurvy due to confinement on a holding island off Singapore, where the brutal dealers used to feed their captives with a bare minimum of vitamin-deficient food for weeks prior to despatch. I have spoken of the hysterias and apoplexies of the dog. The dome-heads are still reckoned the worst flying risks of all; and there is room for investigation here, for boxers and pekes bring in the dollars! Travel fright and air sickness no longer seem to be a worry. The best answer so far to the problem is homoeopathic, and can be revealed to anyone interested. The R.S.P.C.A. pamphlet I wrote on this topic has gone all over the world, and as a result even humans who suffer from these unpleasant concomitants to air travel are using the doggy remedy advocated in that pamphlet.

In bringing this brief survey to a close, it seems necessary to ask the question, why is the provision of aerodrome care of animals in flight not undertaken by the great air corporations and by governments? It should never have been necessary for the R.S.P.C.A. to have intervened as it did to fill the gap by providing humane and decent care for the tens of thousands of animals that pass through London Airport. The conditions there, where so

many national companies from every continent bring and take away animals, make it necessary that the facilities provided for food and water, rest, cleaning, warmth, medical and surgical use, should be centralised in one building. Legislation is urgently needed to enforce the provision of such facilities upon all airports handling animal traffic. I go so far as to say that the time is ripe for the immediate appointment of a veterinary surgeon to take overall charge at London Airport. He should be responsible for the co-ordination and direction of the coming and going of the innumerable exotic species involved. He would study, by accompanying planeloads of animals in flight, their requirements, and his advice would be at the disposal of all corporations and companies using the airport, whether British or foreign. There are black spots in the Far East crying out for guidance in the collection, caging and general care of animals and birds that are destined to come to this country, Europe and the Americas. I can vouch for the fact that a veterinary surgeon is by training and experience the right man for this onerous post. The pioneer work of gaining the confidence of the major transport concerns is already achieved, and they already rely greatly on the advice and opinion of a member of the profession. It is to be hoped that the position gained will not be lost, but that there will be others in the veterinary profession ready to step into the shoes of the pioneers and keep this essentially veterinary activity within the profession.

Summary

This paper describes the steps taken to care for the animals, birds and other zoological species arriving at London Airport by aircraft belonging to all nations. From small beginnings after the Second World War, within a few years the number of animals handled has come to equal the human passengers. During the peak season in summer, anything between 50,000 and 100,000 living creatures pass in a month through the animal hospice erected and maintained by the R.S.P.C.A. at the airport.

The need for overall veterinary control at this and other major airports is emphasised, and the danger of this control passing to lay hands in the future needs to be guarded against. Parliamentary legislation to control this traffic is overdue.

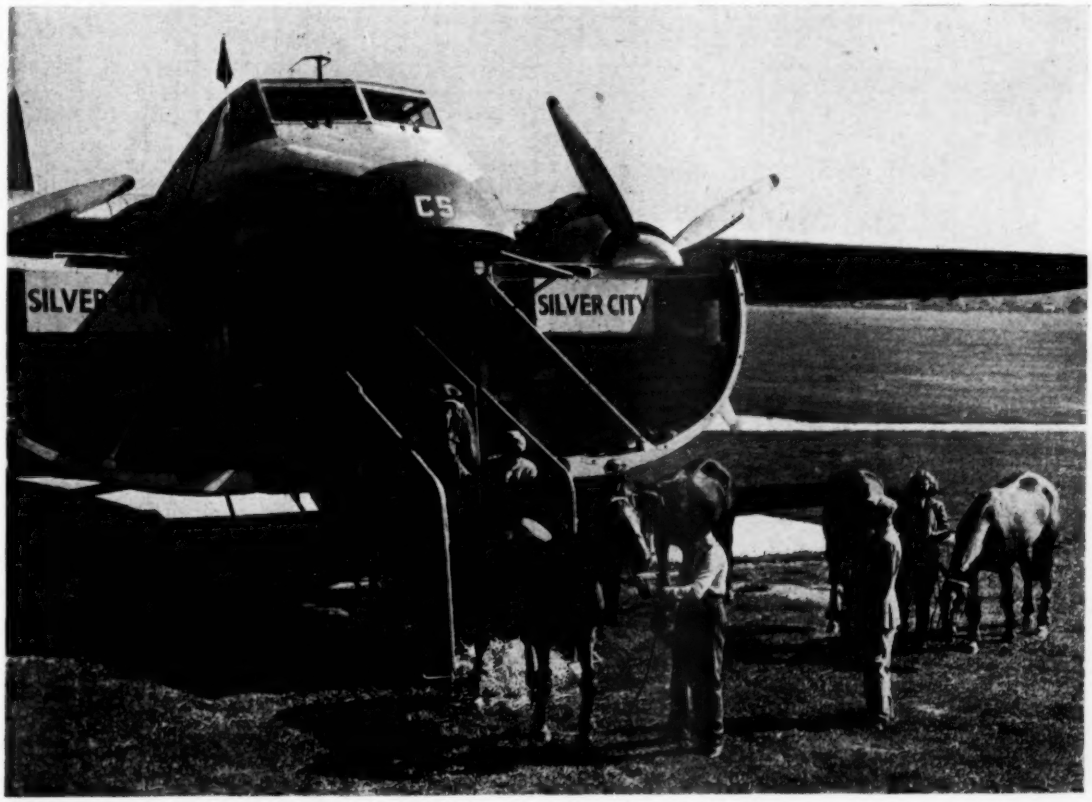


FIG. 5.—Pegasus up-to-date.

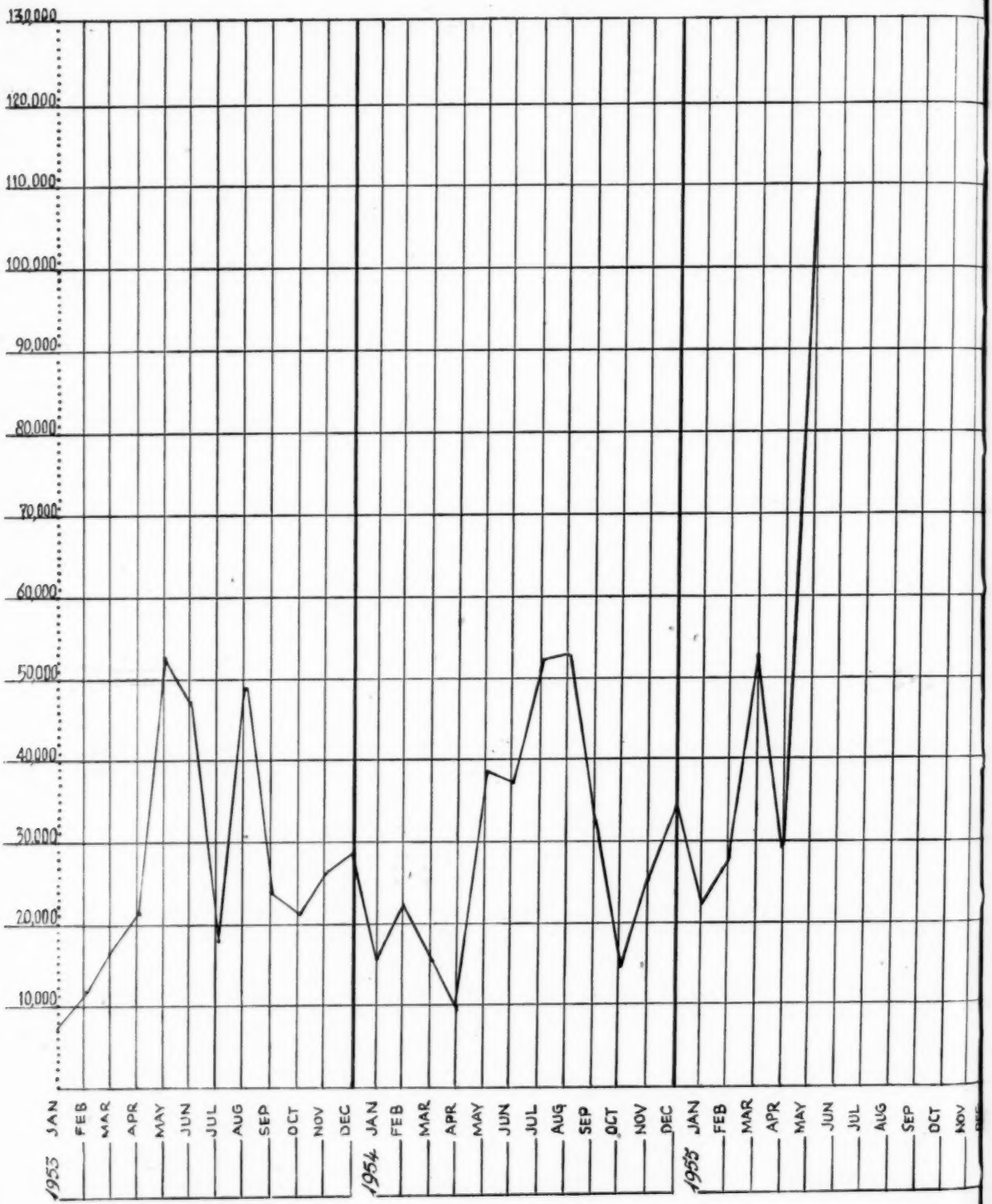


FIG. 6.—R.S.P.C.A. Air Hospice, London Airport, admissions, 1953-1955.

R.S.P.C.A. ANIMAL HOSTEL FOR LONDON AIRPORT

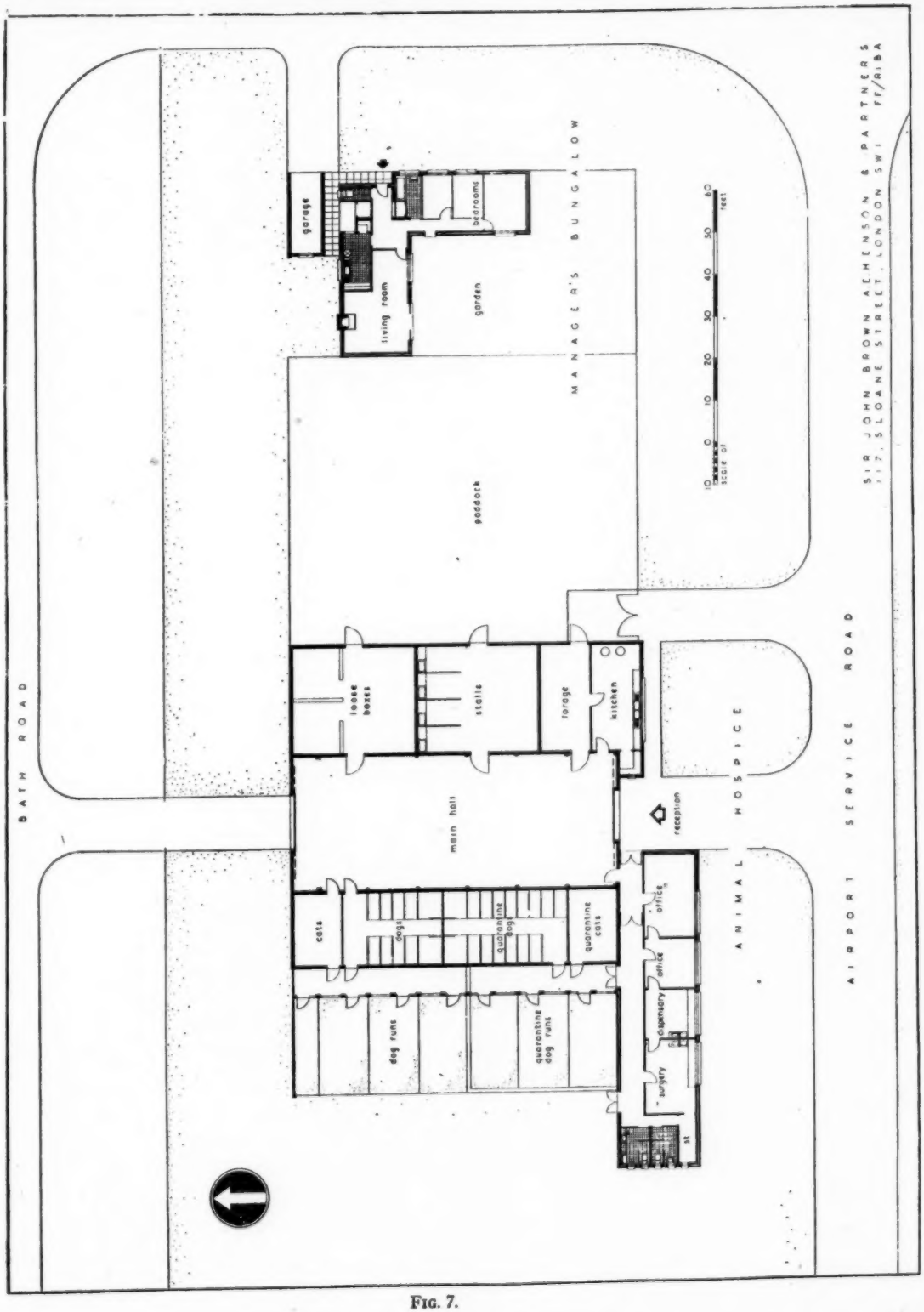

R.S.P.C.A. ANIMAL HOSTEL FOR LONDON AIRPORT
BATH ROAD
AIRPORT SERVICE ROAD
ANIMAL HOSPICE
MANAGER'S BUNGALOW
garage
living room
bedrooms
garden
paddock
loose boxes
stalls
forage
kitchen
main hall
reception
cats
dogs
quarantine dogs
quarantine cats
dog runs
quarantine dog runs
surgery
dispensary
office
office
SIR JOHN BROWN ATHENSON & PARTNERS
7 & 7, SLOANE STREET, LONDON, SW1
FF/RIBA

FIG. 7.

Transport of Animals and Problems Arising. Rail, Road and Sea

BY
JAMES REID
Ministry of Agriculture, Edinburgh

IN 1869 the transit of animals was attracting Government attention, perhaps chiefly because by then the connection was becoming apparent between stock movements and the spread of disease. The outcome was that in the same year a Departmental Committee was appointed to consider the best means of regulating the transit of animals.

The Committee reported in February, 1870, and in May the first Transit Order was made. The provisions were comprehensive and included requirements for the division into pens of places on board ship where animals were carried, regulations for the transit of animals on railways, and for the disinfection of ships and railway trucks. Previously there had been regulations by an Order of Council made under the Contagious Diseases Animals Act, 1869, with respect to cleansing and disinfection of pens, trucks and boats, but none as to the treatment of animals during their passage by sea or land.

Evidently there had been no hesitation on the part of the authorities in making regulations requiring cleansing and disinfection as indeed there had been ample evidence of the indirect spread of the great cattle plagues by means of contaminated wagons and ships; but it required the recommendation of the Departmental Committee to introduce the humanitarian aspect.

It may even be that the prevention of suffering was not the prime factor as is shown by the following report of a Select Committee of the House of Commons (quoted in a memorandum to the Select Committee of 1873 on the working of the Contagious Diseases Animals Act, 1869):—

"A journey whether by sea or rail causes cattle to deteriorate in value and makes them feverish and tends to produce, if it does not actually cause, foot-and-mouth disease. These evils are very much increased if cattle are ill-treated and not properly watered."

To-day, although the prevention of disease is still of prime importance, a great deal of emphasis is placed on the humanitarian aspect of transport.

Another interesting factor connected with the first Transit Order is that in order to ensure that its provisions were carried out, constant supervision was necessary, and in 1874 an inspector was appointed for this purpose. He was called a "travelling inspector" and in the following year additional inspectors were appointed. The inspectors' duties were originally limited to work under the Transit Order, but when rinderpest was re-introduced in 1878, the inspectors were employed in connection with the eradication campaign. In this way originated the present field staff of the Ministry.

The years round 1870 were therefore important in the history and development of animal transport for it was then that the first serious efforts were made to legislate for the control of transportation of livestock. As already indicated, the objects of that early legislation were two-fold; firstly, to prevent the spread of disease by requiring cleansing and disinfection of cattle-carrying vessels, and, secondly, to protect animals from injury while in transit. Those Orders dealt not only with transit, but with the importation of foreign animals. In 1895 transit and importation were separated in the Statutory Orders. Since then many Orders and Amendment Orders have been made in connection with Transit of Animals, *i.e.* cattle, sheep and pigs. Horses are dealt with separately; the first Order relating to conveyance of horses was made in 1909.

In an article of limited length under this title it is not possible to give much space to details of the various Orders which deal with transport of animals to-day. A reference to the main Orders and the purpose for which they exist is given in the appendix. King (1954) surveyed the main functions of present-day legislation relating to transit of animals and horses. Study of the provisions serves to indicate the difficulties and faults encountered and the statutory measures taken to obviate them. It must however be emphasised that although much of the legislation was inspired by humane considerations, the economic aspect could not be completely ignored.

It has to be recognised that in these islands with such numerous livestock, movement of animals is very necessary to assist the farming industry and for other trade and commercial reasons, and that it is not possible to provide individual luxury transport, such as that used for the carriage of valuable race horses, hunters, and other high priced pedigree animals, for the conveyance of commercial-grade stock. The various Transit Orders have minimum standards so that the welfare of less valuable animals is safeguarded.

Despite the reasonable precautions which are laid down by law it is quite impossible to handle the hundreds of thousands of livestock carried for short and long distances over land and sea, including the not always too easy task of loading and unloading, without a proportion becoming injured either accidentally, or frequently, by maiming one another. Encouragement of the present tendency to develop hornless breeds of cattle would make some contribution to the safer transport of animals.

Any attempt to prepare a comprehensive catalogue or to classify the many and varied kinds of injuries

sustained by livestock in transit even with the degree of protection guaranteed to them by law to-day would serve little useful purpose. Some of the more obvious are perhaps bruises and abrasions of any or many parts and of varying significance; damage to the eyes, broken horns, fractured ribs, limbs or pelvis. The more serious of these are not only of veterinary interest but are also of commercial importance. For example, when large numbers of fatstock for immediate slaughter are involved, considerable loss in edible meat and damage to hides may be sustained by careless treatment under certain adverse transport conditions.

Records of animals imported into Britain from Ireland during 1954 show that out of more than 707,000 cattle, 405,000 sheep and 336,000 pigs carried, the total casualties were .03 per cent., .009 per cent. and .12 per cent. respectively. This is not a bad record when numbers are taken into account and also the fact that the casualty figures were adversely influenced by one or two cargoes experiencing gale conditions.

Figures giving the total number of animals carried by rail annually are not available. An effort to translate the weight of livestock carried during last year into numbers can give only a very approximate figure which is perhaps about three to three and a half million. Casualties by rail are not published but they are low.

Although figures for total livestock carried by road transport are not available, it is estimated that the numbers amount to several million, and it can safely be said that the number suffering visible injury is indeed very small. .

The observation (quoted earlier) of the Select Committee of 1873 that "A journey by sea or rail causes cattle to deteriorate in value, makes them feverish and tends to produce, if it does not actually cause, foot-and-mouth disease" is as true to-day as when it was made. That journeying cannot of itself be responsible for the production of a specific disease agent is, of course, better realised to-day, but experience has nevertheless shown time and time again that conditions of common transit are ideal for the development and spread of infectious and contagious diseases.

When infection is present virus conditions such as foot-and-mouth disease and swine fever are rapidly disseminated either directly or indirectly during transport. Close contact provides an opportunity to expose large numbers of healthy susceptible stock to infection. There is, too, additional risk of spread through contamination of vessels, vehicles, trucks and loading banks.

The series of outbreaks of foot-and-mouth disease widely spread over Scotland and England in the summer of 1931, and which originated in cattle from Ireland, illustrates how transport contact and ultimate dissemination of affected, incubating and contact animals multiplies the risk of spread especially of epizootic virus diseases. A more recent example of the rapid spread of foot-and-mouth disease occurred in 1952. Movements of infected animals and subsequent movements of calves (fed during transit on infective milk), and of their contacts, spread disease widely from one centre in Cheshire across England and into several areas in Scotland.

Spread of Newcastle disease, since its reappearance in Britain in 1947, has frequently been attributed to contact between healthy and diseased birds in transit, while in some cases infection appears to have been transferred indirectly by contaminated crates.

The spread of disease in transit is, of course, not limited to virus infections, and it is important to note that where tuberculosis eradication schemes are in operation, the provision of separate facilities for movement of attested stock is absolutely essential.

What happens on a county or country scale can and does happen in the course of more extensive world movements of livestock. Not only are exotic diseases spread by the movement of infected stock, but also through healthy cattle being placed in vessels contaminated by diseased cargoes.

It would be an error to assume that so far as livestock transport is concerned the full debit side of the account has been assessed when the visible injuries, for example, bruises, abrasions, broken horns and bones, etc., and the harmful effects of the spectacular multiplication and spread of disease are examined. There is another side which on closer examination may be of equal, if not of greater importance, to both owners and veterinarians.

Effects of Fatigue

Sea and rail journeying in the opinion of the 1873 Select Committee "causes cattle to deteriorate in value, makes them feverish and the evils" (connected with travel) "are much increased if cattle are ill-treated or not properly watered." The present high price of commercial class animals helps to bring home the accuracy of that statement.

The effect of an ordinary tiring rail or sea journey on man is generally some degree of fatigue which often exhibits itself either physically or by the absence of the usual mental alertness. The effect of travel fatigue is certainly not likely to be any less in the case of the lower animals whose trucks are not provided with special fittings for their comfort.

An animal is in a state of constant interaction with its environment and by means of complex reflexes environmental factors determine the functioning of organs and glands. Every organ or gland which is diseased or, for that matter, functionally upset must in some way, to some degree affect other organs and the whole body. It is therefore possible to argue that the whole individual is liable to be ill or affected functionally by such outward influences as "chill" (used intentionally and in its widest sense), exhaustion, fatigue, bad ventilation and perhaps, not least of all, excitement and fear. All these experiences singly or together may take effect and act as the "trigger" mechanism of many of the sequelae commonly encountered in animals following carriage over long distances.

Analysing the results of the "effect on the milking cow of transport by lorry as shown by the total and

differential cell counts of milk," Macadam (1954) suggests that the findings may reflect increased pathological changes in the glands caused by the traumatic effects of the transport. He concludes "when it is considered that a delicate elastic fabrication such as the udder of the milking cow may contain several gallons of milk under pressure, it is reasonable to suppose that alveolar damage will ensue from the constant violent agitation of the udder during transport of the cow." There would seem to be little doubt that transit fatigue and glandular upsets are predisposing factors in mastitis. Excitement, fear and fatigue on a journey may cause an early and sometimes difficult parturition with harmful effects to mother and offspring.

Among other conditions encountered in animals suffering from fatigue and exposure in course of transit are "transit tetany," a metabolic upset, and "transit fever" in which, probably because of the lowered resistance of the host, normal non-pathogenic pasteurella organisms exert injury. The bacteria infections which may cause enteritis and pneumonia in young calves are commonly spread during transit. Fatigue and exposure aggravate either condition when present.

There is also evidence that in pigs carrying erysipelothrix organisms the balance is sufficiently altered by exposure or fatigue to allow the parasites to exert a pathological effect. This balance can be held in favour of the host and losses limited by an earlier injection of the specific anti-serum.

That some of the conditions encountered respond to present-day therapeutic measures gives some satisfaction to the veterinary surgeon, and that the measures greatly reduce losses consequential to transport should be of some consolation to owners obliged to move stock over considerable distances by road, rail and sea. In these matters not only are stock better cared for during transit to-day but the treatments available for injured or ailing animals show a great advance over those in use less than half a century ago.

Some Mitigating Factors

Among the most beneficial requirements for the well-being of animals in transport can be the prevention of overcrowding, the providing of pens of maximum standard capacity, ventilation of ships, feeding and watering of stock where and when required, and anti-skid flooring requirements. Space does not permit a full examination of all requirements but that does not mean that those omitted are less important or could at any time be ignored.

One condition governing all movements of livestock is that "no animal may be carried if owing to illness of fatigue it will suffer unnecessarily, or in the case of a pregnant animal if it is likely to give birth during the journey or voyage".

A special provision applies to all animals other than horses which undertake the sea journey from Ireland, Isle of Man or Channel Islands to Britain. Such animals are required to have ten hours' uninterrupted rest at the landing place before continuing their journey by road or rail.

There is provision for the transport of an injured or ailing animal under ambulance conditions. This would permit the movement of an animal to a veterinary infirmary or other suitable place for treatment. Rice (1953) made certain suggestions for the transport of injured race horses and hunters.

In recent times much attention has been paid to the treatment in transit of certain classes of livestock. These are:—young calves being carried long distances mostly for slaughter, the aged type of poor conditioned cow (not the decrepit animal) which dealers may sometimes take through several markets in the course of a few days, and the knacker class horse. It is not thought that interference with these three types of traffic would have any adverse effects on livestock trade generally, and it is suggested that any attempt to limit the journeyings of these animals should receive the strongest possible support from the veterinary profession.

The Horses Sea Transport Order, 1952, and the Exportation of Horses (Minimum Values) Order, 1950, have done much to prevent slaughter grade horses being exploited at the expense of their humane treatment.

It will be seen, therefore, that while much advance has been made, there are still certain aspects of transportation of livestock by road, rail and sea, which call for continued vigilance.

What of the future? Large scale movements by air within a measurable period would not appear to be a likely economic proposition. Air transport, if it were desirable and could be developed, would no doubt bring its own problems. With the present indications that sea, road and rail transport will maintain their present importance, every effort should continue to be made, as our knowledge of the well-being and handling of livestock is increased, to improve the lot of animals placed at the mercy of man.

Summary

The earliest legislation to regulate the transport of animals was made in 1870 since when the numbers carried have steadily increased. To-day this side of the livestock trade assumes a high degree of importance not only to the farming industry but also for the maintenance of supplies of milk and meat for the population of these islands.

There are three main aspects of animal transport which, although in some ways interrelated, present separate problems:—

(1) Not only is the injury-free and careful treatment of livestock in transit a matter which receives the constant attention of Government Departments and Animal Protection Societies but it is also a matter of great economic importance to owners. The all-over proportion of livestock sustaining serious injury in transit is very small and is evidence of the care with which animals are now treated and is also proof of the effectiveness of the protection afforded by the requirements of the various Transit Orders. The development of hornless breeds of cattle should help remove one factor responsible for causing damage.

(2) Present-day large scale and long distance transport of livestock presents an easy method of spread of disease. Cleansing and disinfection of vessels, railway trucks and road transport vehicles, are legally prescribed to combat the spread of disease resulting from direct and indirect contact during transit.

(3) In addition to the visible injuries sustained during transit and the possible multiplication and spread of infectious or contagious disease, there is what might be described as the "transit fatigue" factor which lowers the resistance of animals rendering them susceptible to low-grade infections. Though not so obvious a result of transit, this is none the less important.

References

KING, J. O. L. (1954). *Vet. Record*. **66.** 226.
MACADAM, I. (1954). *Ibid*. **66.** 612.
RICE, J. C. (1953). *Ibid*. **65.** 89.

APPENDIX

Animals (Sea Transport) Order of 1930 S.R. & O. 1930 No. 923
as amended by the
Animals (Sea Transport) Amendment Order of 1932 S.R. & O. 1932 No. 727
Provisions for the protection of cattle, sheep, goats, all other ruminating animals, and swine, on sea voyages between ports in Great Britain and ports beyond the British Isles and Channel Islands.

Conveyance of Live Poultry Order of 1919 S.R. & O. 1919 No. 933
Provisions for the protection of poultry in transit by water, rail and road.

Exportation and Transit of Horses, Asses and Mules Order of 1921 S.R. & O. 1921 No. 2008
as amended by the
Exportation and Transit of Horses, Asses and Mules (Amendment) Orders of 1937 and 1940 S.R. & O. 1937 No. 860
S.R. & O. 1940 No. 128

Exportation of Horses Order of 1910 (No. 2) S.R. & O. 1910 No. 976

Exportation of Horses Order of 1919 S.R. & O. 1919 No. 1541
Requirement that all horses shipped from Great Britain to the Continent of Europe shall be examined before shipment; exemption for certain high quality horses; provision for veterinary examination limited to specified ports.

Exportation of Horses (Minimum Values) Order, 1950 S.I. 1950 No. 677
Prohibition of the export to Europe of horses of specified categories below certain values.

Horses (Sea Transport) Order, 1952 S.I. 1952 No. 1291
Provisions for the protection of horses on sea voyages to and from ports in Great Britain.

Transit of Animals Order of 1927 S.R. & O. 1927 No. 289
as amended by the
Amending Order of 9th May, 1927 S.R. & O. 1927 No. 399
Transit of Animals (Amendment) Order of 1939 S.R. & O. 1939 No. 501
Transit of Animals (Amendment) Order of 1947 S.R. & O. 1947 No. 2915
Provisions for the protection of cattle, sheep, goats, all other ruminating animals and swine (*a*) on sea voyages between ports in Great Britain and those in the British Isles and the Channel Islands, and (*b*) in transit by rail in Great Britain.

Transit of Animals (Amendment) Order of 1931 S.R. & O. 1931 No. 750
as amended by 1939 and 1947 Orders above.
Provisions for the protection of cattle, etc., carried by road vehicles.

Transit of Horses Order, 1951 S.I. 1951 No. 1003
Provisions for the protection of horses carried in rail and road vehicles.

Animals (Landing from Ireland, Channel Islands and Isle of Man) Order of 1933 S.R. & O. 1933 No. 20
Inter alia, provision for the regulation of the movement of cattle, sheep, goats and swine imported as above.

Horses (Landing from Northern Ireland and the Republic of Ireland) Order, 1954 S.I. 1954 No. 698
Requirement that horses from Ireland must be examined on landing by a veterinary inspector; landing restricted to specific ports; exemption for certain high quality animals.

THE SPEAKERS' INTRODUCTIONS

The Chairman (Mr. H. L. McConnell): "I have very great pleasure indeed in welcoming Major Hancock and Mr. James Reid, who are to tell us about the transport of animals and the problems arising therefrom. We do not know very much about air transport in Ireland, but we are quite experienced in rail, road and sea transport. I have very great pleasure in asking Major Hancock to say a few words on his paper."

Major R. C. G. Hancock (Berks): "I have purposely written this paper in a somewhat light vein. It is now twenty years since I attended my first Congress, and that at Belfast, and I was conscious even then, and at subsequent Congresses, of how tired of science one becomes by Friday morning.

"As I have pointed out in my paper, the transport of animals by air is a fairly young industry and, with regard to the great air corporations which now operate aeroplanes from London Airport every two or three minutes, I have told you how ignorant they were at first of the principles of animal management, even those apertaining to pets such as dogs and cats, and how more or less completely ignorant they were of the natural history and ecology of the exotic species which now pass through that airport in numbers in the order of 50,000 to 100,000 each month.

"The growth in the last three or four years has been phenomenal and, as I have recommended in my paper, it is high time that we as a profession took greater note of the existence of this traffic and began to think, in terms of the laboratory and ecology, how to better the lot of the unfortunate creatures who all too often (particularly in the Far East) are caught up by some ignorant individual, carried cramped in their thousands in small cages to some seaport thousands of miles away, handed over to a dealer, packed again, often into unsuitable cages, and submitted to some days of air transit before they reach their destination. I can assure you that I am not exaggerating in this paper; the conditions that these animals had to endure is appalling.

"What I particularly want to emphasise this morning is the dreadful dimensions of the monkey traffic. Polio research in the United States of America has developed into such an immense business that nothing short of some 100,000 monkeys a month satisfies the hunger of the research folk who are endeavouring to produce these anti-polio vaccines in that great continent.

"A monkey that has been subjected to three or four days' travelling, starting at a temperature of 140 in the aeroplane when it is waiting to take-off, and going through alternate changes of ice back to a temperate climate, has had a pretty rough time. Anybody who has made a long air journey knows how exhausting that can be. Something to do with the vibrations of the engines or the scream of the jets definitely sets up travel fatigue in the animal and the human. These creatures arrive at London Airport thoroughly exhausted and in need of help; and then, when we have done our best with them at our hospice, they go on to America, mainly, I believe, to supply kidneys for the production of these polio vaccines. One can only hope that it will not be long before the egg adapted virus, or something similar, will take the place of this appalling trade which is apparently necessary to fulfil the programmes of those who are producing Salk and possibly other vaccines against human polio.

"In connection with monkeys, I should mention that since this paper was written and printed the Medical Research Council has shown very grave concern about the monkey

traffic, and initiated an *ad hoc* committee to discuss and recommend measures for the control of the transport of monkeys in India; the modes and ways in which they should be transported, the cages they should be transported in, and the lengths of the legs of each journey to which they should be submitted before they are taken off the aeroplane for rest and recuperation before proceeding on the rest of the journey. I had the good fortune to be the veterinary representative on that committee of the Medical Research Council, and I can assure you that the Medical Research Council in this country is very much alive to the terrible proportions and implications of this traffic, and a set of rules have now been made public governing importation and marketing in this country. This country cannot, of course, control the conditions in other countries, but I think it will probably act as a signpost and an example to those other countries who are using monkeys to a far greater extent than we are here.

"I am very grateful to the Officers and Committee of the B.V.A. for allowing me to have a few illustrations to show you how things are going in this novel form of animal transport. At the rate at which matters are developing, I should think it is very likely that we shall be dealing with more than hundreds of thousands in the coming years. The graph which is illustrating the admissions to London Airport shows some remarkable jerks. In the first year you will notice a drop at the peak period. It so happened that at that time most of the creatures coming in were tropical birds, in tens of thousands, and psittacosis broke out. Some of our staff became affected and the disease broke out later in Petticoat Lane, in London, in some budgerigars carrying the infection. The first big drop in the graph was due to that. There is a long drop through the winter until the Spring of 1954, but it so happened that fog was very bad that year and the drop went lower than it has ever been since. There is another drop towards the end of 1954, and that was largely due to a cargo transport stoppage by B.A.O.C., the main carriers of monkeys in particular. They ran short of aeroplanes and certain animal traffic was held up entirely and diverted to the Continent, so London Airport did not handle it.

"But the numbers we deal with there are surprising. I never anticipated that we should ever get the numbers we do. In a month, as I say, we regularly get 10,000 monkeys passing through our hands, 3,500 canaries, 2,000 Peking robins, 2,500 tropical fish, and 30,000 birds of all kinds. A rather amusing incident which rather frightened our staff was the arrival of 20 'Blackheaded Nuns.' At first we were a little mystified as to why they were sent to the animal hospice, until we realised they were birds!"

Mr. James Reid (Edinburgh): "In his opening remarks, Major Hancock referred to his side of the job as a comparatively new industry. I think I can claim that the side with which my paper deals goes back a lot further than that. There is a record of a certain gentleman called Noah carrying out a very successful operation a long time ago without, as far as I know, veterinary advice or any legal restriction.

"At first glance, the title of the paper, 'Transport of Animals,' may fail to convey to the reader just how important to the country and to the veterinary profession in particular is the safe, humane, fatigue-and-infection-free transport of livestock. However, a clear examination of all aspects of animal carriage and the possible complications and their sequelae does show in no uncertain manner how very closely the work of transporting livestock is related to, and in fact interdependent upon, our veterinary knowledge of the anatomy and physiology of animals, the aetiology of disease and its prevention, and the treatment of the various injuries to which livestock are liable during transit. In the early stages I was in some difficulty in knowing where to begin and, with a limit of 2,500 words, there are very many omissions in this paper.

"From time to time numerous veterinary surgeons, because of their experience in handling animals, have been able to assist in improving the lot of animals in transit. It is perhaps not out of place to mention that one of the greatest contributions to the improvement of the lot of animals carried by road was made by a Belfast veterinary surgeon to whom Professor Lamont referred last night, John Boyd Dunlop, whose name is remembered not for his additions to the store of veterinary knowledge but for his invention of the pneumatic tyre.

"A point in the paper which I have been asked about, and which I would like to confirm, is the reference at the foot of column 1 on page 3 to a series of foot-and-mouth disease outbreaks in the summer of 1931. Without referring to the Ministry's annual reports and speaking from memory, I confirm that that is correct. The only thing that may want clearing up is the point that it originated in cattle from Ireland. Ireland is quite a big island, and I will bring it down to, say, County Down in Ireland, but it is quite accurate that that series of outbreaks originated there, and came over, in cattle, to several ports on the other side.

"I have little more to say; but we, as a people, pride ourselves on our humane attitude to the lower animals and, not without reason, on our disease control measures. It is on a judicious and practical mixture of these that our transport legislation has been evolved. As I have said, this is a very short paper on a subject which could be dealt with at great length. Many will consider that important omissions have been made, and now is the chance to mention them."

The Opener

Mr. J. O. L. King: "The two papers under discussion deal with an important subject, for the movement of livestock is involved in every branch of animal husbandry. In times past farm animals generally travelled on foot at the rate of 12 to 14 miles a day. Even geese from the eastern counties would be driven to London in droves of a thousand or more, arriving after weeks of travelling in good condition, having journeyed over the stubbles, feeding on the fallen corn. Today, however, the movement of animals has been speeded up, and owners now transport their livestock by rail, road, sea and air. Their main concern is that their stock should reach their destination in good condition, in as short a time as possible, and at a reasonable cost. Their choice depends on the efficiency of the service given for a specific journey, and the cost.

"The whole subject has been set out for our consideration in two comprehensive, yet concise, papers, and I should like to congratulate Major Hancock on his excellent contribution on air transport, which includes so much factual information based on his own observations, and Mr. Reid on his admirable paper on the movement of animals by rail, road and sea, in which the important points have been so clearly put.

"Air transport today, as Major Hancock has emphasised, is being widely used for moving livestock long distances, and the recommendation given at the end of his paper that further study by the veterinary profession of the requirements of animals being transported by air is needed, demands attention. During normal flights animals appear to travel well by air, but there are difficulties connected with abnormal flying conditions which have to be combated. For example, it is well known that horses are liable to lie down in their crates if the plane drops in an air pocket, and some method of restraint to check this must be provided. It would appear that the rate at which the use of this form of transport by animal owners increases will depend primarily on its cost, but it will also be influenced by its efficiency, and this will be affected by the speed with which animal accommodation is provided at the airports, and the animal hostel at the London Airport described by Major Hancock should serve as a wonderful pattern for such buildings being erected at those airports normally handling animals. But even airports not regularly engaged in animal transport need to be provided with some accommodation, for a plane might well be grounded unexpectedly overnight, or for a longer period at any airport, and animal passengers might suffer unless they could be housed for this period. Small animals in crates could probably be transferred to another plane without undue delay, but a plane fitted for carrying farm animals could not easily be replaced. The essential accommodation, which should be capable of being heated, might well comprise some stalls for horses and cattle, kennels for dogs and cages for cats, and a room for holding crates containing tropical animals and birds. It is particularly important that crates containing tropical species are not left

about in cold surroundings or exposed to draughts, as their inmates have not become acclimatised to cold, and are easily chilled. The speed of air transport makes it possible for animals to arrive in this country while in the incubative stages of a tropical disease, and so the accommodation provided must be so designed that the animals in transit can be effectively isolated. Fearing the introduction of such diseases, certain countries, for example, Australia and New Zealand, will not allow animals to be imported by air, believing that the sea journey gives them time to show signs of any disease conditions they are incubating.

"Whenever stock have to pass from one premises to another there are always risks associated with their movement; but in considering transport by rail, road and sea, I would like to emphasise Mr. Reid's observation that, considering the large numbers of animals moved each year, there are very few casualties. Mr. Reid has dealt fully with the risks likely to arise from the spread of infection and the effects of fatigue, and so I wish to consider some of the ways in which casualties occur, referring particularly to road transport.

Injuries: "Animal transport is undoubtedly seen at its best in the movement of bloodstock. Considering the excitable nature of the thoroughbred horse in racing condition, and the amount of travelling racehorses are required to do, it is surprising how little trouble is encountered. This satisfactory state is the result of the care which is taken over each individual. The horses are carefully introduced to travelling when young, with a man at their head to soothe their fears; the boxes are carefully designed to reduce jolting to a minimum; and the walls are padded and the horses fitted with protective clothing and bandages to save them from superficial injuries.

"It is not, however, economical to move commercial animals individually in such luxury, and it is usual for animals of the same species to travel together. As they are mostly strangers to each other a cordial relationship does not necessarily follow, and fights take place. This is particularly seen in pigs, for it is the common practice when collecting fat pigs from farms for delivery to a bacon factory to mix the consignments collected. Savaging is the general result, and occasonally fighting may be ferocious. Even though deaths rarely occur, extensive lacerations and bruising are frequently the result. If it were possible to avoid mixing the pigs from different farms, these injuries would not occur.

"Mr. Reid has mentioned that a journey may cause an early and sometimes difficult parturition in cows, and the frequency with which animals very near to, or within a day of two of calving, are moved to markets for sale needs consideration. It says a great deal for the stamina of our dairy cows that trouble does not result more often, but it would obviously be better for a cow, on the one hand, to be allowed a few days to settle in her new surroundings before calving, and on the other to have a week to recover her vitality after calving before being transported to a market. Taking these precautions would not interfere with the assessment of the value of the animals by prospective purchasers.

"The ease and safety with which animals can be loaded into road wagons would be increased if the floors could be made lower, so that the lowered tail-boards would not be at such a steep angle. To carry the weight of a loaded truck at speed efficiently a 30 in. wheel is generally fitted, which means that the floor must be high off the ground, but by sloping the level of the floor behind the back axle slightly and giving a step down on to the tail-board of about 5 in. the angle can be reduced. There should also be a place for some wagons built on 20 in. wheels which would have lower floors. They would be very useful for short journeys where speed is not important, and also for moving lame cattle.

"A construction fault seen in some wagons is that, when the tail-board is down there is a space between it and the back of the floor, in which animals can catch their feet. Cases have been encountered in which upper decks carrying sheep have collapsed, and care is needed in their design and fixing. It would be an advantage if more movable partitions were carried so as to enable different groups of animals of the same species to be separated if necessary. While dealing with the construction of wagons, I would like to add that after use the wood with which they are made becomes worn and it is very difficult to disinfect it in this condition. As it is very important that the routine washing and disinfection after each load should be carried out efficiently it would be a great advantage if it became economically practicable to make wagons of aluminium. Although the cost of construction would be greater, the vehicles would be lighter and therefore cheaper to run.

Ventilation: "The boxes used for transporting racehorses are usually well ventilated, without being draughty, and, as the horses' bodies are kept warm by rugging during winter, it is very rare to find disease resulting from incorrect ventilation. In other cases, improper ventilation during transport may well be a factor in causing disease. On the one hand, there is the trailer pulled behind a farmer's car which, in cold, windy weather may provide scanty protection, and a winter journey in such a vehicle may predispose to pneumonia in calves, adult bovines and pigs. On the other hand, heat stroke has been observed in pigs during transport, the condition being caused by inadequate ventilation and overcrowding. In some consignments numbers of pigs have died on a journey. Transit erythema is also encountered, particularly in pigs being sent on a long journey in an overcrowded wagon. As there is no room for movement the affected pig lies down throughout the journey and urinates in this position.

"Each year very large numbers of day-old chicks are sent by rail from hatcheries to rearers, and very few accidents are recorded. When deaths are encountered they are generally due to faults in ventilation. Most are due to overheating, when a well-intentioned guard puts the box near a steam radiator, not knowing that the heat generated by the chicks' bodies in the small travelling box is sufficient. Occasionally a consignment becomes suffocated as a result of the chick boxes being stacked under other luggage. In very few cases do chicks packed in properly constructed boxes become chilled. By the regulations controlling Accredited and Approved poultry farms, chicks must be sent out in new non-returnable cardboard boxes or similar containers, or in crates which must be disinfected before return or re-use. This reduces the risk of spreading disease through transport.

Feeding: "The greatest weakness in transporting animals, not associated with infectious disease, is probably the long period that they have to go without food and water. Long journeys place a great strain on animals' digestive systems, for if travelling by rail cattle and pigs need only be fed and watered after 27 hours' travelling, and sheep after 36 hours, although horses must be fed and watered at intervals of not more than 12 hours unless the journey takes only 18 hours, when they can be fed and watered after the journey. Animals being transported by sea must be fed and watered if the journey is to take over 18 hours, and after a shorter journey must be placed in lairage for 10 hours to give them time to rest, eat, and drink. Although these periods are long, some animals will not eat and drink in the strange surroundings associated with travel until they are very hungry and thirsty.

"On long journeys young calves particularly suffer through missing a meal, for they are not well equipped to withstand inanition. Their energy demands are high for their size, and they have no reserves of fat on which to draw. The common practice of allowing a calf a large feed of milk before a journey cannot be advised, and does not compensate for missed meals. Feeding pigs immediately before travel may be prejudicial to their health. As pigs are paid for on a live-weight basis, some farmers give their pigs their normal morning feed before being sent to the slaughter house. This is not only unfair to the purchaser, who is paying for food which will never be converted into meat by the time the animal is slaughtered, but pigs travel much better and more comfortably if not fed before a journey.

"The final point I wish to make is that the comfort of all animals while travelling depends to a large extent on the men who are in charge of them. They must be humane and have a comprehensive knowledge of the species of animal with which they are dealing, and must be prepared to adjust the conditions, as far as possible, to meet the requirements of the animals under their care."

The General Discussion

Mr. Oliver G. Jones (London) said he was employed by the Zoological Society of London, and that he represented that body at this meeting. He congratulated Major Hancock and Mr. Reid on their papers. The extent of their subjects was such that lesser men would quail at the thought of writing about them. Mr. King's opening had tied any loose ends which might have been thought to exist. Mr. Reid had made a masterly survey of the machinery involved in complying with the various Acts and Orders covering rail, road and sea transport of animals and of fatigues and diseases which may occur therewith. It was probably lack of space which had debarred him from giving some line drawings of loose boxes, crates, etc., in his paper.

It had been hoped that he would make some reference to the rail and sea transport of specialised animals. There was a vast trade in the export to foreign countries of innumerable animals, such as gazelles, elephants and giraffes, all of which needed very careful attention and very specialised circumstances.

Major Hancock had given a very concise paper packed with information on the air transport of animals.

Mr. Oliver Jones' Society had on all occasions been at pains to assist anybody with any particular problems in connection with the transport of animals, particularly wild ones. The Society had, in fact, published a booklet entitled "Some Suggestions on the Transport of Animals" in 1950. This covered air, road and sea for mammals, reptiles, birds and fish, and was freely available to anybody. Mr. Jones believed the R.S.P.C.A. had asked for and received a copy. It would be true to say that the R.S.P.C.A. had received a great deal of help and advice upon crateage and transport, and upon the equipment and establishment of their wonderful hospice. His Society, to say the least, felt disappointed that no reference was made in Major Hancock's paper to such assistance.

On page 7 of his paper Major Hancock categorically stated that he was against "doping" animals, particularly dogs and cats, prior to flight. Mr. Oliver Jones would have agreed with him had he said that a drug which would cover all species in administration and duration of action was not available, but he heartily disagreed with his principle. Some animals acccpted flying others did not. For the latter some system of sedation and the removal of stress factors, fright and flight reactions was desirable. All were aware of the shock syndrome with its devastating effects, and he did not agree that the "voice that carries reassurance" mentioned by Major Hancock was sufficient to counteract such developments. It did not quieten the racehorse which went mad or the greyhounds with hysteria and apoplexy, both being cases referred to in the paper. The R.S.P.C.A. were quite rightly adamant in their fight to prevent cruelty, and it was a travesty of this crusade to withhold from any animal a pill or potion which would allay a feeling of fear during an animal's flight in an aircraft.

Mr. E. R. Callender (Lytham) said he would like to add his thanks to the two authors for their eloquent papers and to Mr. King for his masterly opening. Most of the information was clear and factual, and there was little to discuss or criticise. Major Hancock was breaking new ground, and few had his experience in connection with the carriage of animals by air.

Mr. Callender had on one occasion inspected a herd of cattle which had been flown from Ireland to England in three Dakotas. He saw them at Liverpool Airport on a warm day and, during the course of his inspection, had the equivalent of a Turkish bath. It struck him that mechanical ventilation was necessary while the aeroplanes were on the ground, because the conditions were certainly difficult; but the pilot of the aircraft assured him that there was nothing to worry about when they were airborne.

Mr. Reid had pointed out that his difficulty was not so much what to include in his paper as what to leave out, and within the limits imposed upon him he had given an excellent paper. He had rightly stressed the possibility of the spread of disease in connection with the transport of animals. He referred to certain outbreaks of foot-and-mouth disease, one of which Mr. Callender was not unconnected with.

Mr. Reid had referred to the spread of disease from Cheshire, and Mr. Callender thought that one or two facts upon this might be of interest. The calves referred to were healthy calves being transported from the South-West of England to Aberdeenshire, and they were fed on milk at Crewe. The outbreak was discovered next day, and from the exhaustive enquiries made Mr. Callender was quite certain that the herd from which the milk was obtained showed little or no evidence of disease when the milk was taken from it. That emphasised the hazards in this connection. The Gowers Committee, which enquired into the outbreak, very rightly recommended that the feeding of milk to calves in transit should be prohibited, and Mr. Callender thought most veterinary surgeons would agree with that recommendation.

Another case concerned a consignment of thirteen healthy cows which were carried in a wagon which the day previously had carried two infected cows. It was known that the thirteen cows were healthy because the home stock stood up and they were still standing up. Some attempt had been made to cleanse and disinfect the wagon, yet it could infect these thirteen cattle with serious consequences, and some thirty or forty outbreaks spread over the Midlands.

It was suggested that Mr. Reid had made an understatement when he said that in some cases of Newcastle disease infection appeared to have been transferred indirectly by contaminated crates. Mr. Callender had a good deal of experience of this disease, and in quite a number of cases had found that it did originate from the use of contaminated crates. He was also satisfied that in many cases where the origin was not discovered the infection had occurred from crates and from the activities of poultry dealers.

With regard to the carriage of a not desirable type of animal, the old cow who had passed her best, the position was improving. It was one of his pet aversions during the war when the amount of unnecessary transport of old cows that occurred throughout the country was deplorable. Cows which had finished their milking life and which should have gone by the shortest route to the nearest slaughterhouse, were taken from market to market in order to enable dealers to make an extra pound. Since the control of livestock and marketing was discontinued, these cows had not undergone so much transport.

Mr. A. J. Wright (Macclesfield) expressed his thanks to the authors and to the opener, and said that it was right and proper that the R.S.P.C.A. should also be congratulated upon the work they had done at London Airport. He supported Major Hancock's remark that it was a reflection that in such a large trade the housing of these animals should be left to an individual society, when it appeared that either the carriers, the airport or some Government department should deal with the matter.

He also congratulated the Ministry upon their continual supervision of transport and upon their efforts in making Acts and Orders to improve conditions of transport.

He made a plea that railway wagons used for transporting attested cattle should be in some way distinguished from the ordinary wagons. Attested cattle should only be allowed to travel in wagons kept specifically for attested animals. It seemed rather ridiculous that the Ministry should go to great lengths in making auctioneers build separate markets and isolation pens before they could have a licence to run an attested market when these precautions were often undone within half an hour of the sale of animals. These attested beasts were taken into wagons which were supposed to have been disinfected, but which were often probably contaminated. In many cases, involving many dealers, they were often mixed up with infected animals. At this stage of the attested scheme, it was high time that some law was made and regulations laid down to separate and identify wagons to be used for the transport of attested cattle. Efforts should be made to obtain the same conditions on the road.

With regard to the construction of wagons for the carriage of cattle, while agreeing with Mr. King that it was ideal to get the floor lower where possible, Mr. Wright crossed swords with him on his suggestion that the back part of the wagon could be sloped down with the ramp at the back falling away from that level. He had seen a number of cattle wagons with a sloping floor in the rear por-

tion, but only recommended them to those who wanted trouble. The animals were usually in a transverse position, and there was terrific pressure on those at the back..

Mr. E. W. Little (Dublin) expressed his appreciation to the authors, and said that this was a very important subject which had hitherto not received the attention from the veterinary profession which it merited. An animal was produced from the farm, a valuable beast in excellent condition, but by mishandling from the farm to the fair, from the fair to the railway and on the railway itself, a large proportion of the profit that should accrue to the farmer was lost.

It had been stressed by the speakers that trouble mainly resulted from the inability of the personnel handling the animals to understand what they should do. It had to be realised that an animal was taken out of its natural environment on the farm, driven to a fair where it had never been before, and handled by strangers and mixed with other cattle, then driven on to the railway loading bank and crowded into wagons. Unfortunately it was in many cases necessary to use a certain amount of rough handling to get animals into the wagons. Every care should be taken to see that there was as little damage done as possible, and in the last fifteen years there had been a great improvement in that direction. A great need in Ireland was the provision of properly equipped fair greens where pens for stock should be provided; fairs held on the streets of towns should be prohibited.

Referring to the history of the movement for the better treatment of animals, Richard Martin, M.P., of Connemara, was responsible for the first Act making cruelty to animals a punishable offence, and was the founder of the Royal Society for the Prevention of Cruelty to Animals. About thirty years after this Act another man who did valuable work in drawing attention to the transport of animals, especially by sea, was Plimsoll, who was responsible for the Plimsoll mark which was to be seen on our ships today. He wrote a book which was published at about that time giving details of the terrible conditions on cattleboats coming from Canada. Temporary floorings were put into the holds of these coffin ships, and the cattle travelled on platforms one above the other. In several cases, in heavy seas, the whole structure collapsed and the boats arrived in Liverpool filled with a mass of dead and dying animals and broken timbers. His exposure of these conditions drew public attention to the transport of animals by sea, although his particular interest was in the protection of the lives of the sailors.

In Ireland a great many cattle were carried by road, but a great many more were carried by rail. In many cases the loading board used for loading cattle into railway wagons was not properly constructed. There was a gap each side of the loading board and an animal could get its leg down between the train and the loading bank. Things had been improved by using a far wider loading board so that when the two doors were held back there was no chance of an animal getting its leg between the train and the loading bank.

In his experience over a good many years, the most common trouble was overcrowding in the wagons. Dealers were always anxious to get an extra beast into the wagon, and anybody superintending that sort of work had no easy task to prevent it. One of the later Acts had set the standard that a man should be able to get into the wagon and get through between the cattle, and, although it was very difficult to set standards in these matters, it had the effect that if a man objected to taking an animal out of a wagon he could be asked to get in and make his way across. In the majority of cases it was found that he could not do so.

Delays in transport were another cause of harm to livestock, and cattle trains were frequently held up at sidings for long periods, especially when awaiting connections at junctions.

The transport of animals was a subject that had in the past been very much neglected by the profession, and Mr. Little was very glad to see that it was receiving more attention.

Mr. J. N. Ritchie (Chief Veterinary Officer) said that he was particularly glad this subject had been brought before the conference. It was a subject which had exercised his Ministry for very many years, and his remarks were confined to the animals which were in his Ministry's charge by virtue of the fact that they were covered by the provisions of the Diseases of Animals Acts.

In controlling the traffic of animals one had to endeavour to devise controls which were practicable. It was not possible to check up on even a sizeable proportion of the journeys which were made. However, the approach of detailing the sort of wagons and vehicles to be used went a long way in at least making the right facilities available to ensure that the animals might be transported comfortably.

He reminded the meeting that in Great Britain the responsibility of supervision lay with the local authorities, and they did extraordinarily well. One who was unfortunate enough to have to travel in the London tube trains was sometimes inclined to be a little jealous of the animal in the tremendous regard which is paid to its comfort in transit.

Some very important and interesting things flowed from this problem in connection with the international traffic of livestock. With regard to the importation of dogs and cats to this country, for which a quarantine period of six months was rightly laid down, it was a fact that with the advent of air transport the effective quarantine period for rabies was substantially reduced by the speedier transit of dogs and cats, particularly from a long distance. In the last number of years there had been some 24 cases of rabies in quarantine, and in at least two of them the disease had appeared later than the six months quarantine period, it being a matter of some good fortune that the animals had not left the quarantine station.

In connection with other types of animals, the set-up in international traffic had to be such as to make it possible for the regulations of the importing country to be observed when the animal arrived; for instance, if the animal was required to go into quarantine. In Canada, animals arriving from this country were quarantined for a period at one or other of two quarantine stations. If traffic by air were encouraged, it would be necessary to set up some sort of quarantine station for the reception of animals coming by air, but it would have to be possible to ensure that the air traffic always reached the airport for which it was intended. In quite a percentage of cases aeroplanes did not in fact land where they were expected, which was a difficult point in so far as the international control of the traffic in animals was concerned.

Mr. Ritchie concluded by thanking the authors for their excellent papers on a subject which was both very interesting and very important.

Mr. J. L. Taylor (Landriss) said that Major Hancock stated in his paper that the R.A.V.C. archives had no information about air transport. He suggested that Major Hancock should contact the Recording Secretary (Mr. R. McCrea) who subject to the demands of military security, would give a lot of information about the air transport of mules for the "Forgotten Army." It was not unknown that many records of the 14th Army were destroyed.

The Zoological Society of London were not the first people whose services to animal welfare had never been adequately acknowledged by the animal welfare societies. There were gentlemen serving with Mr. Richie's department who had been at the ports day and night for many years and they had prevented more cruelty than all the animal welfare societies put together. He worked for the R.S.P.C.A., and everybody sympathised with the objects of that society, so he hoped that Major Hancock would forgive him.

With regard to Mr. Wright's criticism of Mr. King in advocating sloping floors, the point did not arise with cattle if partitions were placed across the trucks to prevent the animals sinking to the back; but with horses, particularly thoroughbreds and hunters, Mr. Taylor had found that sloping floors could be very dangerous indeed.

Major Hancock had not referred to the loading of racehorses into aeroplanes, but the Recording Secretary could have confirmed that it would make it much easier to load a fractious animal into a real aeroplane if one practised with a dummy fuselage before hand. In dealing with mules, one had to ensure that the inside of the dummy fuselage

was painted in the same colour as the real aeroplane because although a mule, like an Irishman, might be a bit backward, he did notice things!

Mr. A. D. Brennan (Surbiton) said that his chief (Mr. J. N. Ritchie) had dealt with those parts of the papers concerning the animals with which he and his staff were dealing, but that, listening to the discussion, he felt there was some misconception about the authorities in this country which dealt with animal welfare. As Mr. Ritchie had said, his Department only dealt with animals under the Diseases of Animals Acts, but Mr. Reid had stated in his paper that it was almost fortuitous that welfare came under the Ministry of Agriculture. He said in his paper that at the time of which he was speaking it was thought that contagious diseases were actually brought about by cruelty and that was why the Ministry of Agriculture was given this power. Mr. Brennan did not wish to pursue this matter, as he was more interested in Major Hancock's paper.

It was pioneering work that was being done, because sooner or later it would become economical to carry larger animals by air. There was no need to rush because at present it could only concern luxury animals, and their owners would see that they were looked after; but legislation governing air travel would have to be made at some time.

Cruelty to animals was dealt with by the Home Office or some other Ministry, so that if propaganda were to be issued it should be made clear that the Ministry of Agriculture could only deal with those animals which came under the Diseases of Animals Acts.

Mr. A. McLean (Belfast) said that he had visited the hospice at London Airport and that it was exceedingly good.

It would be remiss of him if he did not draw attention to the fact that the London Zoological Society had played a very great part in the prevention of cruelty, especially to wild animals. Those connected with zoological societies had been greatly indebted to them. Animals arriving from abroad had been met by officers of the London Zoological Society, fed and watered, and then properly despatched to Ireland some week or ten days later. They had played a very great part in the prevention of cruelty and he wished to acknowledge that publicly.

Mr. L. F. Robertson (Tanganyika) said he would like to speak on a point which had been referred to but which had possibly been skimmed over. He was glad to hear that it did not particularly refer to this country but, apropos Mr. Ritchie's remarks concerning the adequate supervision of the transport of animals by the local authorities, he stressed the need for supervision of the transport of animals outside this country. One did find that even when regulations existed they might not always be fulfilled, largely because senior officials did not quite know what was going on and junior officials did not realise the importance of reporting to them certain conditions. He had recently been stationed in a place which was a railway terminus. About 100,000 head of cattle were transported by that railway each year and he was horrified to find that a large number of animals were arriving at the terminus with fractured pelvises because they had slipped on the wagon floors. On checking a number of the wagons it was found that they had no form of floor battens or any other means of preventing the animals slipping through. The animals might have had to travel for two or three days. It eventually transpired that not a single wagon in the whole railway system had the provisions required by the regulations. In some areas people were very well meaning but a trifle ignorant of what was required. He stressed the need not only for adequate legislation but for adequate supervision of transport bodies in order to ensure that the legislation was carried out.

Miss O. Uvarov (Cobham) said she was particularly grateful to Mr. Reid for calling attention to the effects of fatigue. In practice that side of the question had perhaps been underestimated. It appeared that the physiology of fatigue was not clearly understood; this applied particularly to fatigue after travelling. She asked if Mr. Reid could suggest any preventive measures to combat fatigue. Speaking of individual small animals, it was difficult for those in practice to make any suggestion when asked for advice. She had read the abstract of a recent Japanese publication in which it was reported that some work had been done on the subject and it had been estimated that in cattle exposed to fatigue there was a certain lowering of the Vitamin B complex, particularly B_{12}. She asked Mr. Reid if he had any information on similar work in Great Britain or if he had read this report. (Sahashi, *et al.* (1953). *J. Biochem.* Tokyo, 1953, **40**, 245-249).

Mr. W. F. Tweed (Chester) said that for years it was thought that erythema in pigs in transit was due to lime, urine or disinfectant burning from the trucks, but in many of these cases the condition was due to sarcoptic mange. When pigs were crowded together and got warm, itching developed and they rubbed their buttocks on the floor giving the appearance of having been badly scalded.

In road transport, lorry drivers avoided stops if possible to prevent pigs fighting. With unshorn sheep there was a danger of suffocation from overcrowding.

He asked Mr. Reid if anything could be done which would prevent commotion, cruelty, and difficulty caused in loading animals in markets.

There were no regulations requiring that stock carried by road should be watered; in fact this might be unpracticable, but animals could be carried from one market to another by road and not get access to water in the markets.

Mr. J. Marshall (Barnsley) made a plea that the British Veterinary Association should produce a handbook giving the various authorities some guidance on the construction of crates and vehicles for the transport of animals.

The Replies

Major Hancock replying to the discussion, said that the papers had been so generously dealt with that neither he nor Mr. Reid could reply to all the points which had been raised.

Legislation was needed in the matter of air traffic. He had gone to the Roseberry Committee prepared to give evidence on the air transport of horses only to be told that there was no likelihood of anything but the luxury racehorse being transported by air in the future and that therefore legislation was unnecessary. Within three years it had become clear that that was an incorrect assumption. The number of horses carried by air was becoming quite large and by no means all of them were of the highest class or of great value. Hunters, and horses going to shows, were often transported by air to Europe and even to America. "Foxhunter" was a classic example of a horse that would lie down, and he would fight and nearly kill everybody around him if they tried to put webbing under his belly to stop him lying down. They had to have an especially large loosebox in the aeroplane or he would wreck it. A good many *ad hoc* arrangements were necessary even in considering only the horse.

The ventilation of aeroplanes was a very difficult matter. The more up-to-date aeroplanes had a wonderful array of electrical gadgets under the freight compartment which forced out, drew in, pressurized and conditioned the air. When loading monkeys in India the air temperature was often 145 degrees F. and if there were a delay before the aeroplane took off it was a terrible experience for the monkeys and for those who had to travel with them. The pilots and staff were not allowed to meet their fellows in social conditions at London Airport until they had gone through a process of deodorisation and had obtained a fresh set of clothes. Travelling with monkeys was a most unpleasant business.

He apologised to Mr. Oliver Jones and his Society if he had not given adequate prominence to the very great help they had given, particularly when the hospice was being constructed. Major Hancock had called on Mr. Jones's specialised knowledge and skill very freely and he was very grateful to him.

With regard to the doping of animals, when he wrote his paper Major Hancock had in mind the many animals which were brought to the hospice at London Airport destined for India or even Australia which even then were coming round from what was obviously the effects of a barbiturate or something similar. They were crying, moaning and throwing themselves about the boxes. One could imagine nothing worse than an animal which had probably been asleep when it left the surgery arriving at an airfield in a half-doped condition and, due to delays in transport, being put in an aeroplane in a half-dazed condition. If a "dope" had been produced that would keep an animal asleep for the calculated travelling

time, he would have been the first to recommend it. He did not regard the sedatives and anaesthetics for animals which were given by veterinary surgeons to anxious owners who ran into the surgery just before the aeroplane left as satisfactory. He regarded them as a source of additional suffering.

The lack of animal accommodation at major aerodromes was beyond his understanding. So many ministries were involved in the building of the London Airport Hospice, that they often did not know who to go to for consultation during the building period. He imagined that the tenant using the land should be responsible, in the same way that a railway company would be responsible, for seeing that the animal passenger accommodation was adequate. He thought that just as first aid was provided for fainting females on Waterloo Station so it should in like proportion be compulsorily available to animals at all airports.

In connection with monkeys, he added that there was a proposition afoot that they should avoid coming to this country and make the journey from India to America nonstop in long-range aeroplanes. That was going to be productive of terrible fatigue and was too much to ask any wild animal which had been recently caught to endure. The Medical Research Council were gravely concerned about this proposition which would also have the effect that the kindness and succour which was poured upon these creatures at London Airport in an endeavour to relieve their distress, would no longer take place. That was perhaps a secondary consideration but with the present freight planes available it was a grave matter that the direct journey of over 48 hours to the United States should be envisaged in the near future.

In answer to Mr. Taylor's remarks with regard to the archives of the Royal Army Veterinary Corps, he had done his best to obtain information but he was told from Droitwich that no records existed. He had stated that in his paper in all good faith.

Miss Uvarov had emphasised the importance of fatigue and he entirely agreed that the matter required investigation. There were a great many factors involved about which little or nothing was known, but nervous exhaustion was met every day in the case of animals travelling by air.

With regard to Mr. Reid's paper, a transport vehicle which was very good for horses and which was attached to the back of a vehicle was the Rice trailer. It had the advantage which many speakers had said was essential. The axle did not run through the vehicle but there were stub axles on either side. It conveyed two horses only a few inches from the ground and the ramps were virtually horizontal. The animals went in at the back and walked out at the front without having to be turned or backed. It was a well-designed vehicle and was very largely used to take horses to and from hunts. He had used it for transporting horses to and from various horses homes and he thoroughly recommended it as a low loading trailer with practically no slope for the animals to negotiate when they entered.

Mr. Reid in replying to the discussion, agreed with Major Hancock that the number of points raised could not be amply dealt with in the time available.

In his opening Mr. King had emphasised the feeding and watering of stock in transit. Everybody was strongly in favour of ensuring that stock were properly treated during transit.

Three other points which had been mentioned were overcrowding, injury and the carriage of pregnant animals.

Overcrowding was an offence although there might be difficulty in proving the offence. It was a question of opportunity or degree. Mr. Ritchie had referred to the London tube and anyone who had experienced it in the rush hour would think that the lower animals were not too badly treated.

It was also illegal to put on road, rail or sea any animal which could not be carried without suffering.

Pregnant animals should not be put on lorry, rail or boat if it was likely that they would calve before ending their journey, but it had to be a very clever man who could time that to a matter of minutes or even hours.

Mr. Brennan had explained to Mr. Oliver Jones why the carriage of elephants, tigers, etc., had not been mentioned in the paper.

There was a suggestion that advice laying down measurements and other points in transit, should be prepared. That would be very nice and might be of some help but he came back to Mr. King's point that so much depended upon the man in charge of the animals. Even with an out-of-date truck a man could carry stock perhaps not too comfortably but with care, and the same applied to the master of a ship. It was up to the people in charge to see that animals were properly carried.

Mr. Wright had made the point that trucks should be restricted to the carriage of attested stock only. No one but the railways would quarrel with that and they were already in sufficient financial difficulties. It would be unreasonable to expect the railways to provide separate trucks if the same were not also applied to road transport and he could not see how that would work. The rules relating to disinfection in the attested herd scheme had to be relied upon.

Mr. Reid was grateful to Mr. Ritchie, Mr. Brennan and Mr. Callender for amplifying certain points. They had made his reply much easier and had helped him to cover matters which he had either skimmed over or did not have space to mention in his paper.

On Miss Uvarov's question he could not be helpful and could only advise careful handling. He had no knowledge of the Japanese paper but he thought that the fatigue factor had not been sufficiently studied. As stock was developed and more production expected from it, this point would have to be more closely examined.

Mr. Tweed had asked whether he could offer any advice on making the loading of animals more simple and safe in markets. He did not know whether Mr. Tweed had in mind the provision of permanent loading banks. He did not know how that would work but it was worth consideration.

He was grateful to Major Hancock for mentioning the Rice trailer which was ideal for ambulance purposes. He did not know but it might be satisfactory for calf transport.

Hormone Control of the Oestrous Cycle

BY

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1. Reproductive Periodicity in the Female.
2. Patterns of the Oestrous Cycle.
   a. Spontaneous and post-copulatory ovulation.
   b. The central nervous system and terminal follicular maturation.
3. The Influence of Environmental Factors on Sexual Periodicity.
   a. Photostimulation and sexual periodicity in birds and mammals.
   b. The influence of temperature on sexual rhythms.
   c. The refractory period.
   d. The mode of action of light.
4. Effects of Stimuli associated with Courtship and Mating.
   a. Psychological factors.
   b. Brain functions in mating behaviour.
5. Hormonal Control of the Oestrous Cycle.
   a. The hypophyseal-gonadal axis.
   b. Control of FSH, LH and LTH (prolactin).
   c. Pre-ovulatory luteinisation.
   d. Induced gonadal cycles.
6. Oestrus and the Central Nervous System.
   a. The influence of the corpus luteum.
   b. Gonadotrophic potency of the pituitary.
   a. Blockade of ovulation.
7. The Relationship of the Nervous System to the Release of Gonadotrophin and the Regulation of the Sex Cycle.

IT is well known that the complex phenomena attendant upon the initiation of the sexual cycle of vertebrates include changes in the endocrine balance and involve several very specific hormonal effects. Indeed, the reproductive rhythms of the female can well be regarded as constituting one general category of behaviour that is perhaps more clearly influenced by endocrine substances than any other aspect of animal life. Nevertheless, it would be a mistake to assume that reproductive behaviour is unaffected by, or is completely independent of, ecologic and neurologic phenomena. On the contrary, there is good evidence that the secretion of certain of the interacting hormones is mediated, at least in part, by the nervous system and that the whole mechanism may be influenced or inhibited by nutritional and environmental factors.

It is apparent, therefore, that at least three types of controlling factors have to be considered in any explanation of the processes which take place in sexual cycles, namely hormonal, neurological and ecological. But, in view of the extent to which the effects of all these factors are integrated, any sharp segregation of them can be justified only as an expedient in the exploratory consideration of a subject which, despite many recent advances, must still be treated tentatively.

1. Reproductive Periodicity in the Female

The seasonal release of eggs or embryos from the ovary is the most common reproductive pattern among the fishes. As a general rule, copulation and the birth of young occur most actively during the spring and summer, while the female reproductive tract is relatively quiescent in autumn and winter. A seasonal wave of reproductive activity is also typical of many amphibia and the same is, in general, true of reptiles and birds, though certain tropical reptiles and some domestic species of birds breed rather continuously throughout the year, without any indication of a seasonal rhythm.

In the non-pregnant, post-pubertal, female mammal, reproductive capacity manifests itself by the cyclical occurrence of structural changes in the reproductive organs and in the cyclical repetition of periods of sexual receptivity or "heat" during which the animals are said to be in "oestrus". Monoestrus animals complete a single oestrous cycle annually, while polyoestrus forms complete two or more cycles each year if not interrupted by pregnancy. In some (spring breeders, *e.g.*, horse, donkey, carnivores, insectivores and autumn or winter breeders, *e.g.*, goat, sheep and deer) these recurring cycles may be limited to a part of the year; in others (*e.g.*, cow, guinea-pig and many rodents) they may occur uninterruptedly throughout the year. The duration of the cycle itself varies considerably, but in all species the cycle ceases after the ovaries are removed.

Many wild mammals exhibit monoestrous cycles. In the bitch, the oestrous cycle is repeated twice each year (Evans & Cole, 1931; Griffiths & Amoroso, 1939; Amoroso, 1949; Hancock & Rowlands, 1949; Rowlands, 1950). In cats prevented from becoming pregnant, recurrent oestrous cycles appear only during a portion of the year, usually from January to July or August. There is a possibility that confinement is responsible for some modification of the reproductive cycle since, in animals kept under laboratory conditions, heat periods may not occur at regular intervals, though occasional females may maintain a regular two- or three-week cycle during spring and summer. In the cat also, the duration of oestrus varies greatly from individual to individual and even in the same individual from time to time. Each cycle may require as little as three days for completion after the first copulation (van der Stricht, 1911), while in the absence of the male the period of sexual receptivity will often continue for a week or even longer (Liche, 1939; Mellen, 1946).

Pseudopregnancy occurs after any non-fertile ovulation whether brought about by a sterile mating (Gros, 1935; Liche, 1939), by mechanical stimulation of the cervix (Dawson & Kosters, 1944; Amoroso, 1952) or by hormonal treatment (Foster & Hisaw, 1935; Rowlands & McPhail, 1936; van Dyke & Li, 1938 and others). When so

induced the uterine changes which follow parallel, with some slight retardation, those found at the time of implantation of fertilised ova. The duration of this pseudopregnancy is, however, very variable. Thus, Gros (1935) finds that after sterile copulation with a vasectomised male, the active phase of pseudopregnancy lasts about 23 days after ovulation and the regressive phase about 10 days; the female is in oestrus again by the 40th day. These data are in general agreement with our own and with those of Liche (1939), who states that pesudopregnancy lasts 36 days. On the other hand, Foster & Hisaw (1935) report an active phase of 30 days in a pseudopregnancy induced by the injection of FSH and LH, while, according to van Dyke and Li, pseudopregnancy is no longer present 20 days after hormonal induction of ovulation. These data on hormonally induced pseudopregnancy in the cat are thus much more variable than those derived from sterile mating or from mechanical stimulation of the cervix.

In the bitch, Evans & Cole (1931) state that glandular regression appears to begin about the 20th day of metoestrus with the uterus usually in repose on the 90th metoestrous day. Probably, as Asdell (1946a) states, it is too gradual to set any definite limits. No obvious differences in the cellular content of smears taken during pregnancy and pseudopregnancy have been observed (Hancock & Rowlands, 1949).

2. Patterns of the Oestrous Cycle

a. *Spontaneous and Post-copulatory Ovulation.*

The dominant event in the oestrous cycle is ovulation. It is a phenomenon which is initiated in the gonads through the action of the gonadotrophic hormones and its time of occurrence is usually regarded as the most important reference point in the cycle from which such things as changes in the ovary, uterus, vagina and sexual behaviour may be dated and correlated. In many species of mammals, for example, cow, sheep, goat, mare, sow and bitch, ovulation occurs spontaneously and is ushered in by a short period of very rapid follicular growth, commonly referred to as the pre-ovulatory swelling. (See Table I.) In others—the induced ovulators—the final enlargement of the follicle, the secretion of liquor in quantity and ovulation require an additional stimulus, either actual coitus or simulation of the coital stimulus by mechanical irritation of the cervix. (See Table II.)

b. *The Central Nervous System and Terminal Follicular Maturation.*

Post-copulatory ovulation is normal in the rabbit (Hammond & Marshall, 1925), 13-lined ground squirrel (Foster, 1934), short-tailed shrew (Pearson, 1944), cat (Greulich, 1934; Gros, 1935; Dawson & Friedgood, 1940; Amoroso, 1952), ferret (Hammond & Marshall, 1930), mink (Enders, 1939; Hansson, 1947), racoon (Llewellyn & Enders, 1955), and it may be taken as established for the rabbit, and as a strong possibility for the other forms, that sexual excitement affects LH secretion by nervous reflex activation of the anterior pituitary (Marshall & Verney, 1936; Deanesley, Fee & Parkes, 1930). There are thus at least seven species in which post-copulatory ovulation is known to occur. That this represents a phylogenetic series may be questioned, but from the reproductive behaviour of allied species we should not be surprised if, as more individuals from different families are investigated, the condition is found to be more widespread than is known at present (*soridiidae, sciuridae, mustelidae* and *felidae*), and was long believed to exist in man as well, until finally disproved comparatively recently (Eckstein, 1949). In many fishes, amphibia, reptiles and birds also, ovulation occurs after a more or less complicated series of courtship encounters, and it is quite possible that these sexual displays have a direct bearing upon ovulation and that in many species ovulation would not occur in the absence of such sexual experiences.

The stimulus necessary for ovulation may vary a good deal. For example, although ovulation is ordinarily post-coital in the rabbit, Hammond & Marshall (1925) found that oestrous females occasionally ovulate after mounting other females in masculine fashion, and since the same response may be obtained by manual stimulation of the vulva, cervical contact is regarded as unnecessary. In the cat also, mechanical stimulation of the cervix can simulate the coital stimulus as was first shown by Greulich (1934).

The intensity of the necessary stimulus for ovulation, as indicated by the duration of sexual congress, is also variable. It is comparatively brief in the rabbit, squirrel and cat; protracted, rough and violent in the ferret, while in the short-tailed shrew ovulation occurs only if a relatively high number of copulations have occurred. One or two copulations a day do not induce release of the ovum, and the least effective number of matings recorded is 19 (Pearson, 1944).

But, even in species in which ovulation is generally considered to be independent of mating, there is reason to believe that secretory function of the pituitary is influenced by stimuli derived from copulatory activity and is dependent on a chronologically limited neurohumoral stimulus to the hypophysis that is qualitatively similar to that in the rabbit and cat. Thus, Everett, Sawyer & Markee (1949) demonstrated that in cyclic rats ovulation can be blocked either by intravenous injection of Dibenamine or by subcutaneous injection of atropine before 2.0 p.m. on the day of pro-oestrus (four-day cycle). Similar treatment at 4.0 p.m. does not usually interfere with ovulation. Identical results, with similar time relationships, have been obtained with intravenous SKF.501 (Sawyer, Markee & Everett, 1950a), subcutaneous Banthine and the barbiturates (Everett & Sawyer, 1950). In the cow also, Quinlan, Bisschop & Adelaar (1943) report that infertile coitus shortens the oestrus cycle, while copulation is said to hasten the occurrence of ovulation (Marion, Smith, Wiley & Barrett, 1950).

There is also good reason to believe that the secretion of the luteotrophic hormone (LTH) or

prolactin with consequent prolongation of life of the corpus luteum and the secretion of progesterone is involved in the copulatory activities of the rat. In females of this species, ovulation is followed by the formation of numerous large corpora lutea, but if no mating has occurred these structures are non-functional and do not secrete progesterone. If, on the other hand, the oestrus female is mated to a sterile male, the ensuing corpora lutea are functionally active and pseudopregnancy results. It is evident, therefore, that stimulation of the cervix in the rat is necessary to start the chain of reactions, and it determines whether the oestrous cycle shall consist merely of a succession of waves of ripening follicles, or whether the dioestrous interval in which the corpora lutea are active, shall separate these waves (Asdell, 1946b). This is, as Asdell suggests, obviously a mechanism which economises hormone synthesis and results in greater opportunity for fertilisation and implantation. It should, of course, be recorded that it is more than a quarter of a century ago since Long & Evans (1922) reported that pseudopregnancy may be induced in the female rat by mechanical stimulation of the vagina and cervix with a glass rod, as well as by infertile copulation.

Other illustrations of the importance of nervous mechanisms to the endocrine control of the reproductive cycle of mammals are to be found in observations on the oestrous cycle of the cow. This animal has a relatively short heat period averaging about 13½ hours. According to Asdell (1946), when threshold doses of oestrogens, not more than the amounts needed to induce heat, are injected daily into ovariectomised cows, the resulting oestrus is not continuous, but ceases at the usual time in spite of the continued injection. Evidently, the length of the heat period is curtailed by the induction of a refractory period in the brain and this causes sexual desire to cease. This interpretation is in general agreement with Herren & Harterius' (1931) observation that central reflex time increases under the influence of oestrogens, suggesting that the hormone in some way modifies the relative excitability of the constituent neurons of the nervous centres concerned, either by affecting specific enzyme systems or indirectly through alterations in the distribution of electrolytes.

This phenomenon in the cow has an interesting consequence. Ovulation is spontaneous in this animal and occurs after she has gone out of heat, usually about 13 hours thereafter. The average threshold dose of oestrogens necessary to bring a cow in heat is very low, about 600 rat units. This is apparently reached early in the development of the graafian follicle and the refractory period sets in before the follicle is sufficiently grown for it to rupture. Thus, there is an interval in which heat has ceased before ovulation occurs.

There are certain other peculiarities in the oestrus cycle of the cow that distinguish her from the other farm animals. For example, uterine bleeding occurs about 24 hours after ovulation; this is unusual. Again, the life span of the corpus luteum during the cycle is about 18 days, that is to say, it is somewhat longer than is usual in most mammals; this greater length appears to be correlated with a high LTH or prolactin content of the anterior pituitary. The cow is again exceptional in the high degree of homosexual behaviour she exhibits when in heat.

3. The Influence of Environmental Factors on Sexual Periodicity

A number of facts about animals suggest the intervention of some agencies tending to adjust their reproductive activities to a special season of the year, thus ensuring that the young are born at the most propitious time. Marshall (1935; 1942) was the first to emphasise the dependence of the breeding season in many species on environmental or "exteroceptive factors" and he suggested that such factors exert their effects by nervous and reflex stimulation of the secretion of gonadotrophic hormones, primarily FSH, from the anterior pituitary.

Of the factors that influence reproduction and anchor the breeding cycle, light, temperature and the environmental experiences derived from association of the sexes are considered to be of the first importance (Amoroso & Matthews, 1955). On the other hand, howsoever favourable the environment, one cannot but agree wholeheartedly with Beach's (1948) insistence that the development or flexibility in the control of sexual behaviour and the consequent reduction of control by stereotyped anatomical and hormonal mechanisms, as a result of the transfer of function to cortical mechanisms, has been a pre-eminent evolutionary process in the progress from lower mammals, through those of intermediate phyletic status to man.

a. *Photo-stimulation and Sexual Periodicity in Birds and Mammals.*

Birds. There now seems to be overwhelming evidence that sexual periodicity in numerous species of temperate zone birds is somehow controlled by light and dark fluctuations (Amoroso & Matthews, 1955). Encouraging egg production by subjecting hens to increasing rations of light is, indeed, an old Spanish custom (Rowan, 1936). But, while the duration and intensity of light are important, they are not the only factors involved in the seasonal activities of birds. For example, there is evidence of the cycle being reset by factors other than light, since Fraps, Neher & Rothchild (1947) showed that under constant light the rhythm of egg laying in the domestic fowl could be reset by changing the times of feeding.

Mammals. As with birds, the length of day and night, the exposure to artificial light and darkness and temperature are known to have important influences on the regulation of the oestrous cycle and sexual behaviour in mammals. The ferret has a long autumn-winter period of sexual quiescence, or anoestrus, from August or September until March. Without artificial manipulation of lighting cycles or hormone treatments, ferrets have not been known to breed during that period in the northern hemisphere. However, sexually inactive ferrets, as Bissonnette

(1932); Hill & Parkes (1933); Marshall (1940); Thompson & Zuckerman (1953; 1954; 1955) and Donovan & Harris (1954) have shown, do become reproductively active in winter when subjected to artificially lengthened periods of light, females being more completely controlled in this way than males.

In rats also (Fiske, 1941), it appears that light causes a greater output of follicle stimulating hormone than luteinising hormone, since females receiving additional rations of light remain in an oestrus condition for several weeks instead of the normal period of 14 hours. Moreover, immature females kept in the light from birth or from the 21st day of life come into sexual maturity about six days earlier than normal and 16 days earlier than those kept in the dark.

Burkhardt (1947) has shown, in a series of controlled experiments, that oestrus and ovulation followed by pregnancy could be induced in anoestrus mares by general irradiation with strong artificial light. Moreover, there was a close connection between the shedding of the coat and ovarian activity and, since the mares were confined to their boxes during the period of irradiation, exercise could not be a factor.

Among wild species, racoons can be induced to breed in December instead of February by increasing autumn lighting (Bissonnette & Csech, 1937) and the same would appear to be true of the white-footed mouse (Whitaker, 1936), the hedgehog (Allanson & Deanesley, 1934) and the vole (Baker & Ranson, 1932a; 1932b; 1933), though in the latter, food and probably latitude might alter the response, winter-type food being best; earlier activity farther north. Finally, in the American marten, in which there is a delayed implantation of seven months in a pregnancy which lasts nine months, Enders & Pearson (1943) have shown that, by gradually increasing the lighting rations from September onwards, early implantation could be induced—the animals whelping in December instead of April. Pearson & Enders (1944) suggest that increasing day length stimulates the pituitary to secrete hormones which in turn evoke the elaboration of ovarian substances essential to implantation.

All animals do not, however, show the same sensitivity to waxing and waning of daylight hours. Thus, while in most species an artificially lengthened day advances the breeding season, in others, for example, the guinea-pig (Dempsey, Meyers, Young & Jennison, 1934), the ground-squirrel (Moore, Simmons, Wells, Zalesky & Nelson, 1934), the rabbit and cow, such treatment has, so far, failed to show any definite effects, suggesting that these species seem to have freed themselves wholly or partly from this particular environmental influence. Furthermore, Bissonnette (1941) reported that the breeding cycle of certain breeds of goats is controlled by light in such a way that increasing daily light periods from January 25th to April 5th, followed by decreasing light until July, resulted in the cessation of oestrous cycles in February instead of March and the resumption of oestrus in May and June instead of September. We may conclude, therefore, that in the same animal light can have double effects; promoting gonadal activity, or bringing the season to a close and blocking further stimulation. Moreover, many mammals such as the horse, donkey, cat, ferret, etc., have "long-day" breeding seasons in the spring, whereas others, like the sheep, goat and deer, breed during the autumn or "short-day" season. Thus, if light be regarded as stimulatory to the former, then it is inhibitory to the latter.

Marshall (1942) points out that internal sexual rhythms are usually adjusted to external seasonal changes and in general a species indigenous to one hemisphere adjusts its breeding season to the new calendar when it is moved across the equator, so that within a year or two the time of the new breeding season coincides with the previous period of sexual repose (Marshall, 1937; 1942). Tropical and sub-tropical animals customarily display less restricted seasons; but even in some non-varying tropical lands, seasonal reproductive cycles may be observed.

b. *The Influence of Temperature on Sexual Rhythms.*

Temperature may affect the endocrine activity and, therefore, behaviour of constant breeders (Steinach & Kammerer, 1920) and in some animals it seems to be more important than light. In the male ground-squirrel investigated by Wells & Zalesky (1940), gonadal development is not modified under laboratory conditions by extra illumination, and animals maintained at laboratory temperatures experience practically the same seasonal cycle as those under field conditions. In the wild state, testicular regression is associated with rising summer temperatures, whereas seasonal activation coincides with the diminishing temperatures of autumn and winter. Further proof that temperature does have a marked effect on testicular rehabilitation is given by the observation that breeding males kept at 40°F [$t°F = 5/9\ (t - 32)°C$] for one year remain in breeding condition throughout this period, the sexually quiescent phase of the cycle failing to appear. Also Erb & Waldo (1952), reviewing the evidence relating to dairy cattle, concluded that in areas where high environmental temperatures are common during a portion of the year, breeding efficiency declines in summer. The summer depression in the production of both milk and butterfat has, likewise, been known for a long time.

c. *The Refractory Period.*

Emphasis upon the major effects of seasonal changes in light, temperature, rainfall and similar environmental factors upon the reproductive cycle of seasonal breeding animals should not preclude recognition of the fact that, however favourable the environment for reproduction, there is a period which follows breeding in which it is impossible for another sexual cycle to be restarted. This has been called the "refractory period" (Bissonnette & Wadlund, 1932).

We do not know with certainty what specific factors, either external or internal, operate in bringing about this refractory state. The view of refractoriness proposed by Marshall (1950; 1951;

1954) is based upon histological changes in the avian testes under natural lighting. He believes that the refractory period is due to the end of the life-cycle of one generation of Leydig cells, and that its duration is determined by the time required for the next generation to mature. It is, however, possible that the gonads merely reflect pituitary activity. In birds, refractoriness has been studied in the starling (Burger, 1947), duck (Benoit, Assenmacher & Walter, 1950), golden-crowned sparrow (Miller, 1951), the junco (Wolfson, 1952) and in the bower bird (Marshall, 1954) and in mammals its existence in the mink has been claimed by Hammond (1951 ; 1954).

d. *The Mode of Action of Light.*

Certain experiments made by Bissonnette (1930 ; 1931a ; 1931b ; 1932 ; 1933) with the ferret indicate that the eyes are the avenues of reception of light. Unlike the duck (Benoit, 1936 ; 1937 ; Benoit & Ott, 1944), the ferret does not respond to light after the optic nerves have been cut ; the animal still displaying an inherent sexual rhythm which is independent of light and hence does not progress in accordance with seasonal change. However, although the integrity of the optic nerve is necessary in the ferret, neither the visual cortex nor the mid-brain is essential to the gonadal light response (Clark, McKeown & Zuckerman, 1939 ; Zuckerman, 1947).

On the other hand, there is little doubt that the visual stimuli are conveyed to the anterior pituitary through the central nervous system and that a close physiological relationship exists between the hypothalamus and the pars distalis of the pituitary, but the exact nature of hypothalamico-pituitary transmission is controversial. Harris and his collaborators in several publications (Harris, 1948 ; 1950 ; 1952 ; Harris & Jacobsohn, 1952 ; Donovan & Harris, 1955) have advanced the view that in mammals the proximate stimulus for the specific activation of the secretory cells of the pituitary gland is a chemical substance which is discharged from certain hypothalamic neurons that constitute a specific "sex centre" (Markee, Everett & Sawyer, 1952): This chemo-transmitter substance passes down the axons and diffuses into the capillary loops of the hypophyseal portal vessels whence it passes into the sinusoids of the anterior lobe (Harris & Jacobsohn, 1952). It must be pointed out, however, that Zuckerman and his co-workers (Zuckerman, 1954 ; 1955 ; 1955b ; Thompson & Zuckerman, 1954 ; 1955) are unyielding in their view that the timing mechanism that regulates the phasing of the gonadotrophic action of the anterior lobe is independent of the integrity of the hypophyseal portal circulation and "these vessels are neither a sufficient explanation of, nor necessary for, certain of the responses in question" (Zuckerman, 1955b).

4. Effects of Stimuli Associated with Courtship and Mating

a. *Psychological Factors.*

It now seems likely that, in addition to physical stimuli, many psychological factors have profound effects upon the breeding cycle in birds and mammals. There is overwhelming evidence that many species of birds and mammals, although perfectly healthy and in an apparent state of complete physiological well-being, fail to exhibit seasonal periodicity and never breed in captivity. Something appears to be lacking in the psychological climate that either inhibits or fails to stimulate the regular seasonal gametogenesis associated with breeding activities (Amoroso & Matthews, 1955).

The elaborate courtship rituals of many species of vertebrates are a striking example of psychological stimuli that affect the breeding cycle. In many birds, the cycle—pairing, nest building, copulation, ovulation, incubation and the rearing of young—fails to occur unless the traditional ritual is adhered to. Indeed, so stereotyped are these sequences of events that, if they are interrupted, it is necessary for the participants to restart the ritual in all its detail for successful breeding to occur.

Darling (1938) and Tinbergen (1951) have studied the effect that the total numbers of individuals have on the efficiency of the breeding activity of sea-birds that nest in colonies. Darling has shown that within limits the larger the colony the higher the percentage of successful hatchings, and that there is a minimum density of numbers in the colony below which there is little or no success in breeding. He further suggests that in some sea-birds that nest gregariously, the period of egg-laying is more protracted in small colonies than in large ones, since the necessary stimulus to breeding is weaker in the small colony.

Darling studied chiefly the herring-gull, but also extended his observations to the fulmar which, as Fisher (1952) has shown, is gradually extending its breeding range in the British Isles. It is usual for this species to appear in numbers at new nesting sites on the margins of its breeding range, and for the birds to show every apparent intention of breeding ; but no eggs are laid or young reared until the colony has built up in numbers to the necessary minimum, a process which may extend over several years. Accordingly, it is suggested that an essential stimulus is lacking until the number of birds in the colony attains specific minimum size.

The importance of numbers in influencing the breeding cycle through psychological stimuli is very great in those species in which there are communal nuptial displays, such as the blackcock, fulmar, ruff and some species of albatross. It has been suggested that the widespread reduction in numbers of the blackcock throughout the British Isles in recent years, although it is due primarily to coccidiosis, is in part brought about by a secondary consequence of the disease, which has left a population too thinly spread to allow the necessary psychological stimuli to be built up through concentration of birds on their breeding grounds (Amoroso & Matthews, 1955).

It is probable that the route by which the psychological stimuli act upon the gonads is via the hypothalamus and the hypophysis. In many female birds, ovulation is not spontaneous, but depends upon the appropriate releasers being presented by

the sexual partner. Thus, Harper (1904), Craig (1913) and Matthews (1939) have shown that visually isolated female pigeons with auditory and olfactory access to other birds do not lay eggs; whereas, females with mirrors in their cages, or those placed so that they can see other pigeons, do oviposit. Similarly, Roberts (1940), who studied the breeding behaviour of various species of penguins, concluded that visual stimulation provided by other individuals contributes materially to regulation of the reproductive cycle in these birds. This author suggests that stimulation arising from the male's courtship display contributes to the induction of secretion of ovarian hormones essential to the female's sexual activities.

Also directly related to the problems under immediate consideration are observations which indicate that some birds (*e.g.*, sparrows and flickers) which normally lay a relatively small number of eggs and then become broody, may be induced to produce 10 times the normal complement if the newly laid eggs are removed promptly (Witschi, 1935). Similarly, Roberts (1940) found that the female penguin lays new eggs to replace those that are removed; but if small stones are substituted for the plundered eggs the replacement interval is prolonged.

The possible importance of such stimuli appears to extend even to the male. Thus, Witschi (1935) reports that the male pigeon exhibits crop gland secretion if he is able to see an incubating female; and Taibell (1928) states that a turkey cock which was tied down on a nest of eggs quickly became broody and returned to incubate the eggs after being released!

Little is known about the importance of psychological stimuli in the breeding cycles of mammals, though they probably play as large a part in regulating the cycle in many species of mammals as they do in birds. In many species of seal there is a characteristic harem system on the breeding grounds (Amoroso & Matthews, 1952; Davies, 1953), whereby a dominant male becomes the proprietor of a number of females which he guards against the attention of rival males. In all these species there is a *post-partum* oestrus during which sexual congress is permitted and it is possible that such colonial enterprises are highly important to the achievement of normal reproductive function in these carnivores. A harem system is also employed by some ungulates, and it has been suggested, but not proved, that the stag of the red deer herding his harem of hinds, and challenging or even sparring with rival stags, provides the necessary pituitary stimulation to induce oestrus in his hinds.

Heape's (1901) observations on captive animals in zoos led him to suggest that in various species the presence of the male stimulated the female to oestrus; while that of the female stimulates the male to rut. Similarly, the stimulating action of "teasing" or "heckling" by the male mink as a factor contributing to early breeding each season is emphasised by Beach (1948).

The foregoing considerations make it clear that the environment exercises a profound effect on the physiological functions of reproduction, but the exact manner by which changes in environmental temperature, light, food supply and social impact affect gonadal development is not surely known. Surgical removal of the pituitary gland abolishes the normal seasonal cycle in many mammals and birds and renders the gonads unable to respond to environmental factors, which normally activate them. This indicates that the hypophysis is a necessary link in the chain of reactions which leads to sexual activation. There is little doubt also that the gonad-stimulating potency of the hypophysis increases during the period of normal or artificial reactivation of the gonad. Thus, it appears that the seasonal cycle is conditioned by certain external environmental factors which excite or inhibit the secretion of gonadotrophins by the anterior pituitary and make it possible for reproduction to occur at the appropriate breeding season. It must be admitted, however, that there is a serious gap in our knowledge regarding the effects of environmental conditions on the neuro-endocrinological systems of farm animals.

b. *Brain Functions in Mating Behaviour.*

Just over 80 years ago Goltz (1874) reported in Pflügers Archives that bitches deprived of both cerebral hemispheres are capable of fertile coition and the same has been shown to be true of female cats (Bard, 1936). Among rodents, too, copulatory reactions have been shown to survive after decortication in female guinea-pigs (Dempsey & Rioch, 1939) and in female rats (Beach, 1943; 1944; 1952). Beach's analysis has been the most extensive and in what follows some of his main conclusions are summarised.

One index to sexual receptivity in the rat is the ease with which the female can be induced to display the lordosis response which is essential to the male's achievement of intromission. The "copulatory quotient" is a score based upon the number of times the female responds with lordosis when she is mounted by an aggressive male. This measure, Beach found to be unaffected after partial or total loss of the cerebral cortex. He found also that such individual differences as were present in the pre-operative scores tended to persist after brain injury. It was otherwise, however, with the males. After removal of various amounts of the neocortex, male rats become sexually less active. The reduction is progressive as lesion size increases; the amount of cortex destroyed and not the precise locus of injury being the critical factor.

Rats that failed to copulate after brain operation could be made to do so when injected with testosterone if the brain lesion is small. It has been suggested, therefore, that the cerebral cortex acts as an excitatory mechanism which elevates levels of activity within lower neural centres specifically concerned with the mediation of copulatory behaviour. When large amounts of cortical tissue are removed there is a reduction in responsiveness of the lower centres to exteroceptive stimulation and sexual behaviour is unlikely to occur. These

same executive centres may also be stimulated by androgen, and under appropriate circumstances the loss of excitability occasioned by restricted cortical invasion may be compensated by artificial elevation of the normal androgen level (Beach, 1952).

These observations suggest that the rôle of the cerebral cortex in masculine and feminine sexual activities may not be the same and this is confirmed by studying male and female coital reactions shown by the same individual animals (Beach, 1943). Female rats, like female rabbits and the cow, often exhibit male-like copulatory responses when placed with a second female that is in oestrus. The most common masculine responses are mounting and clasping the other female. Females showing this behaviour are in no way abnormal. When they are in oestrus they respond in accepted fashion to the approach of the male.

We have already seen that feminine responses do not diminish following removal of all the cortex. However, partial destruction of this brain region tends to reduce masculine responses in female rats and total decortication completely eliminates the tendency altogether. Thus, within the same individual, the masculine and feminine patterns are separately mediated, and by decortication one can be eliminated without materially affecting the other.

In cats, as in rats, the male's coital performance depends heavily upon the cortex of the brain and cannot be carried out in the absence of this part of the central nervous system. However, unlike the male rat, the partially decorticated tom cat may evince marked sexual arousal even though he is unable to carry out the necessary reactions involved in coitus. This latter point undoubtedly reflects the increased corticalisation of sensory and motor functions in which the carnivore differs from the rodent.

5. Hormones in the Control of the Oestrous Cycle

The morphological aspects of the oestrous cycle have been very carefully studied in a number of our common laboratory and domestic mammals and the specific action on the female reproductive tract of a number of hormones known to be concerned have been well established (Asdell, 1946a). What has not been so carefully investigated nor so fully understood is the physiological interaction of the endocrines responsible for the development and co-ordination of the observed cyclic phenomena.

The internal secretions that take direct part in regulating the oestrous cycle are those of the ovary and the gonadotrophic hormones of the anterior pituitary, while other endocrine glands, *e.g.*, the thyroid and adrenal, whose products are more directly concerned with the general metabolism of the body, exercise an indirect though important influence.

a. *The Hypophyseal-Gonadal Axis.*

It is generally agreed that the changes in the reproductive organs that regulate the physiological and psychological aspects of the breeding behaviour of mammals and birds are conditioned by the internal secretions of the gonads and the activities of the latter are, in their turn, predominantly under the control of the pituitary (Smith, 1927; 1930; Smith & Engle, 1927; Ascheim & Zondek, 1927).

If the female mammal is deprived of her pituitary, both the gametogenic and endocrine functions of the ovary are impaired. After hypophysectomy these organs rapidly deteriorate and consequent atrophic changes appear in the accessory reproductive structures. The daily administration of pituitary extracts or implants of fresh pituitary to the hypophysectomised animal restores the ovary to normalcy. It is, therefore, reasonable to regard the pituitary as the essential source of the gonadotrophic hormones in the adult non-pregnant female and the gonads and accessory reproductive organs as the foci of their action. The gonadotrophic hormones are three in number, namely, the follicle stimulating hormone (FSH), the luteinising hormone (LH) and the luteotrophic hormone (LTH) or prolactin.

b. *Control of FSH, LH and LTH.*

Moore and Price (1932) were among the first to put forward the view that the cyclical nature of the oestrous cycle was due to the humoral interplay between the ovaries and the anterior pituitary. There is now a good deal of evidence in support of the suggestion that the secretion of follicle stimulating and luteinising hormones (FSH and LH) by the anterior pituitary are under separate control and that the gonadotrophic potency of the anterior pituitary is modulated by a feed-back mechanism in which the determining factor is the level at which the ovarian hormones are secreted (Zuckerman, 1955a). Thus, when its concentration in the blood rises, the oestrogen that is secreted by ovarian tissues under the influence of FSH inhibits the further secretion of FSH and, provided that its concentration does not rise too far, stimulates the further release of LH. FSH secretion may be envisaged as occurring initially in amounts sufficient to initiate follicular growth in the ovary. Under the increasing influence of LH, follicular maturation is completed and oestrogen production continues. Ovulation is then induced, followed by corpus luteum formation. At this stage the luteotrophic hormone (LTH) is responsible for maintenance of the corpus luteum and the secretion of progesterone (Astwood, 1941). Ovulation thus occurs as a result of the combined action of oestrogen and progesterone on the follicle.

The discharge of luteinising hormone from the pituitary seems to be inhibited by high titres of progesterone. The corpus luteum remains functional for only a short period unless pregnancy or pseudopregnancy supervenes. Regression of the corpus luetum may occur because of a self-limiting factor in the corpus itself, since there is no evidence of a cyclic change in pituitary leuteotrophin production. It is of interest that, at least in the hypophysectomised immature rat, oestrogens may act like FSH and maintain follicular development (Williams, 1944a, 1944b). Moreover, since both FSH and LH do not physiologically act as single entities at

TABLE I.

(After Eckstein, 1949)

THE CHARACTER OF THE OESTROUS CYCLE IN DIFFERENT MAMMALIAN SPECIES.

	Species	Length of cycle	Length of heat	Ovulation	Corpus luteum of the cycle	Presence and duration of pseudo-pregnancy	Pregnancy	Miscellaneous
A.	Rat	Mean = 4.8 days Mode = 4 days	13.7 hours 9–20 hours	Spontaneous towards end of heat	Very short-lived. ("Non-functional") Deciduomata cannot be induced	Present. 12–14 days. (Deciduomata can be induced)	21–22 days	Well-defined vaginal cycle
	Mouse	Mean = 4.5 days Mode = 4–6 days	(Similar to rat)	Spontaneous during heat	,,	Present. 10–12 days. (Deciduomata can be induced	18–20 days	? Moderate oestrogen production
	Golden Hamster	Mean = 4.3 days	1.5 days	,,	,,	Present. 9–10 days. (Deciduomata can be induced)	16 days	
	Wood Mice Deer Mice, Cotton Rat	All similar to first three						
B.	Guinea-Pig	Mean = 16.5 days	12 hours	Spontaneous during heat	Functional (?) 10–13 days Deciduomata can be induced during cycle	Absent	67–68 days	Well-defined vaginal cycle
	Chinchilla	(?) 24 days	2 days	(?) ,,	(?) Functional	(?) Absent	111 days	
	Nutria	(?) 27–29 days	?	?				
	Pig	21–22 days	2–3 days	Spontaneous during heat.	Functional, ca. 15 days.	Absent	112 days	
	Cow	20–21 days	13–14 hours	Spontaneous, but 13–15 hours *after* end of heat	Functional, 15–20 days.	,,	280–290 days	Low oestrogen production. Mucification of vagina. Mucus ++
	Zebu	21–23 days	4.8 hours (!)	?Spontaneous	?	(?) ,,		(?) Even lower oestrogen production than in cow
	Sheep	16.5 days	1–2 days	Spontaneous during heat	Functional, ca. 14 days.	,,	148–150 days	
	Goat	19–20 days	39 hours	,,	(?) Functional.	(?) ,,	150 days	
	Mare	19–22 days (variable)	5–7 days (!)	,,	Functional, 15–17 days.	,,	ca. 330 days	(?) High oestrogen produc.
D.	Virginian Opossum	ca. 28 days Seasonally polyoestrous	1–2 days	Spontaneous during heat	Functional, ? 8–10 days.	Present	12.5 days	Large number of eggs shed at ovulation
	Marsupial Cat (Dasyurus)	No oestrous cycle Seasonally monoestrous	1–2 days	,, ? 5 days after heat	Functional.	Present ca. 2 weeks	? 8–14 days	No true placenta
E.	Dog.	No oestrous cycle Seasonally monoestrous	ca. 7 days	Spontaneous during heat	Functional.	Present Similar to pregnancy	58–63 days	Pro-oestrus bleeding (By diapedesis)

separate times, their individual actions are chiefly of academic and chemical interest.

This simple endocrine interaction outlined above may not, however, be the whole explanation, since pituitary transplants grafted on to the cortex of the temporal lobe of the brain may become well vascularised, but fail to maintain oestrous cycles. This is taken by Harris (1950) as evidence that the hypothalamus and intact hypothalamo hypophyseal connections are also of importance. Moreover, Dempsey (1937) does not believe that oestrogen is the controlling factor, since he found that the rhythm of the cycle proceeded without interruption after either short or long-continued injections of oestrogens. He believes that the secretion of FSH occurs at a nearly constant rate during the cycle and that the release of LH is accomplished either by some basic rhythm of the pituitary itself or in consequence of a rhythmic discharge from some mechanism, possibly the central nervous system.

c. *Pre-ovulatory Luteinisation.*

The concept that the secretion of progesterone begins during the period of follicular maturation known as the pre-ovulatory swelling receives further support from studies upon the fluctuations in the amount of water contained in the uterine tissues during the normal cycle. This effect is part of a more widespread pattern of change in water content which the hormone stimulates in most tissues of the body (Zuckerman, Palmer & Hanson, 1950).

In addition to the hyperaemia and cellular growth which it induces, another characteristic effect of oestrogen upon the reproductive organs of the female rat is to increase the amount of water in the tissues of the uterus, but this response is inhibited by the simultaneous action of progesterone. The water content normally reaches a maximum shortly before pro-oestrus and falls abruptly immediately before ovulation (Astwood, 1939; Carroll, 1945), suggesting that oestrogen induces some reversible change either on the capillary wall, the lymphatics, or the extra-capillary tissue, which determines the retention or otherwise of extra-cellular water. The immediate cause of the pre-ovulatory dehydration is believed to be due to the increased secretion of progesterone, which opposes the action of oestrogen upon the uterus. These facts suggest that secretion of progesterone by the follicle begins about the time of sexual receptivity and it is interesting to note that, beginning with Bischoff's (1845) description of the ovary of the bitch, certain changes have been described in the walls of the ripe follicles in the cat (Dawson & Friedgood, 1940), rat (Boling, Blandau, Soderwall & Young, 1941) and mouse (Allen, 1941) which may be regarded as luteal in character.

d. *Induced Gonadal Cycles.*

In natural environments there is a basic tendency for females to permit copulation only during recurrent periods, but sexual behaviour may appear if such cycles are artificially induced at times when they would not ordinarily be expected to occur.

TABLE II.

(After Eckstein, 1949)

REPRODUCTIVE PATTERNS OF ANIMALS IN WHICH OVULATION DOES NOT OCCUR SPONTANEOUSLY.

Species	Sexual Periodicity	Ovulation (in hours after coitus)	Occurence and duration of Pseudo-Pregnancy	Duration of Pregnancy (in days)	Miscellaneous
Rabbit	Continuous heat (occasional dioestrous intervals)	10	Present 15–16 days	31–32	
Ground-squirrel (Foster, 1934)	Recurrent oestrus-like periods of 2 to 4 weeks length	8–12	?	27	Comparatively short copulation
Ferret	Continuous heat	42	Present 5–6 weeks	42	
Mink (Hansson, 1947)	(?) Continuous heat	36–37	Present	49–51 (very variable)	Delayed implantation
Cat	Continuous heat, but follicles may degenerate spontaneously, so terminating oestrus	24–30	Present ca. 36 days (very variable, Gros, 1935)	63–64	Ovulation can be induced by mechanical stimulation of cervix
Mole Shrew (Pearson, 1944)	Continuous heat	About 64	(?) Present 9–10 days	18	Repeated coitus necessary to induce ovulation

Induced sexual activity may thus occur as a direct result of the administration of gonadal steroids, or the normally inactive gonad may be stimulated by the administration of appropriate gonadotrophins.

It might be argued that the induction of sexual behaviour out of normal season by gonadotrophic treatment offers no evidence to support the belief that such reactions depend upon gonadal hormones, and this is obviously true. However, the effects of gonadectomy strongly suggest that the presence of the gonads is essential to normal mating behaviour and there is some evidence to indicate the direct action of steroid hormones upon sexual responses. Shortly after the isolation of the follicular hormone, oestrogen, it was shown that it was capable of inducing the characteristic behaviour patterns and morphological changes associated with oestrus. It soon became apparent, however, that the phenomena induced by oestrogen were only partial or irregular and fell short of the counterpart events in the normal reproductive cycle. Thus, uterine growth and proliferation of the vaginal epithelium can be induced in ovariectomised animals by oestrogen alone, but for the full differentiation of the uterus and for the full development of vaginal proliferation typical of the normal cycle, progesterone also is required. Similarly, both ovarian steroids are involved in the ovulatory mechanism and are also required for full proliferation of the mammary gland.

In female guinea-pigs, oestrogen alone can induce oestrus, but only in a fraction of the animals. The latent period is long and the response irregular and atypical. On the other hand, when oestrogen is followed by the administration of progesterone, oestrus is invariably produced, the latent period is short and the duration and quality of the response is normal.

Cattle do not follow the same pattern of behaviour in response to oestrogen therapy. In a small experiment designed to study the effect of stilboestrol on the cyclic cow (Hancock, 1951), it has been shown that oestrogenic activity of the substance was displayed only when it was administered during the follicular phase, or after the decline of the corpus luteum. That is to say, when its effects were added to and inseparable from the endogenous circulatory oestrogens. In these animals the succeeding oestrus tended to be unduly prolonged. When the animals were treated at any time after the first week in the cycle, ovulation failed to occur and sexual behaviour was erratic.

Hammond (1938) reports induction of fertile mating in mares during the winter by injection of chorionic or pituitary gonadotrophins. Heat follows hormonal treatment after an interval of 24 hours and ovulation is normal. Day (1940) also has elicited normal sexual behaviour in dioestrous mares by the administration of horse pituitary, and, according to Hammond & Day (1944), heifers implanted with oestrogen pellets frequently come on heat as a result of such treatment.

Among the carnivores, Friedgood (1939) states that female cats, during the period of normal anoestrus, exhibit spontaneous courtship, mating and post-copulatory ovulation following the administration of FSH plus LH. Windle (1939) has also elicited follicular growth, mating and ovulation in anoestrous cats by administering chorionic gonadotrophin and similar results have been obtained in pregnant queens (Amoroso, unpublished data). Leathem (1938) showed that pituitary gonadotrophins could induce all the signs of oestrus including vulval swelling, bleeding and mating in anoestrous and metoestrous bitches and Greenblatt & Pund (1941) report similar results in bitches injected with human chorionic gonadotrophic. We have ourselves found the gonadotrophins of human menopausal urine to be an effective substitute for HCG. That the behavioural changes induced by these sundry methods are traceable to ovarian hormones is indicated by the fact that gonadotrophic treatment of the spayed bitch is without effect (Leathem & Morrell, 1938) and by Leathem's additional observation that mating behaviour can be induced following oestrogen treatment and by the further suggestion of Hancock & Rowlands (1949) that stilboestrol can be used to accelerate the onset of oestrus in parous bitches when "heat" has been delayed.

6. Oestrus and the Central Nervous System

The duration of oestrus depends upon several factors.

In the first place, the existence of a refractory condition in the central nervous system leading to a heat period of definite length has been postulated (Asdell, 1946). In an animal like the cow such a state is apparently reached early in the development of the graafian follicle and the refractory period sets in before the follicle is sufficiently ripe for it to rupture. This, according to Asdell, may account for the unusually short oestrus in the cow (13 to 14 hours) and for the fact that in this species ovulation occurs regularly after, not during, heat as in almost all other animals (the bat may also be an exception to this rule). The same worker has drawn attention to Zuckerman's work (1938) on the rat which showed that recurring heat episodes could be induced by means of continuous threshold oestrogenic stimulation.

a. *The Influence of the Corpus Luteum.*

In the second place, it is clear that the active corpus luteum must exert an important influence on the length and general pattern of the cycle. It is a well-established fact that this structure can suppress oestrus, but the mechanism by which this is effected is less well understood. That it may interfere with follicular maturation and ovulation either directly or through the anterior pituitary have been advanced as possible explanations (Loeb, 1923; Asdell, 1928; Robson, 1947); on the other hand, removal of the corpus luteum, either during the cycle or during pseudopregnancy, causes a precocious return of oestrus in most animals (*e.g.*, rat, guinea-pig, cat, cow, mare).

b. *Gonadotrophic Potency of the Pituitary.*

Another major factor is related to the anterior pituitary. A number of investigations have been

carried out to determine the activity of the anterior pituitary in different species of mammals with the object of explaining the variations in reproductive behaviour shown by them. In the domestic animals an interesting chain of events has been found. In general it may be stated that the length of oestrus is directly related to the FSH content of the anterior pituitary, the more FSH content per unit weight of pituitary, the longer is the average heat period for the species. The threshold of oestrogens necessary to bring the females into heat follows the same pattern and so does the level of oestrogen excretion. The series in descending order is shown in Table III. The presence of cyclic variations in the gonadotrophic potency of the pituitary correlated with the oestrous cycle was first observed by Wolfe (1931) in the sow. He found the activity of the gland to be maximal during the period of pre-ovulatory swelling, considerably less during oestrus and minimal when active corpora lutea were present in the ovaries.

TABLE III
(After Eckstein, 1949)

The Hormone Content of the Anterior Pituitary in Different Species (in decreasing order)				The Duration of Oestrus in Different Species	
Gonadotrophic Activity.	Follicle Stimulating Hormone.	Luteinising Hormone.	Luteotrophic Hormone (Prolactin).	Species.	Length of Oestrus.
(Chance *et al.*, 1939).	(Witschi, 1940).	(West & Fevold, 1940).	(Chance *et al.*, 1939).		
Horse	Horse		Sheep	Mare	5-7 days
Pig	Pig	Sheep	Ox	Pig	2-3 days
Sheep	Sheep	Pig	Pig	Sheep	30 hours
Ox	Ox	Cattle	Horse	Cow	13-14 hours

In the cow, as can be seen from Table III, the hormones are the same as in the other animals, but their amounts and balances differ. In general, the cow has the lowest concentration of pituitary and steroid hormones. Moreover, she is more sensitive to these hormones than any other animal, and consequently much more care must be exercised when cattle are treated with them.

7. The Relationship of the Nervous System to the Release of Gonadotrophin and the Regulation of the Sex Cycle

Nearly 20 years ago Marshall & Verney (1936) obtained the first direct evidence that the central nervous system might be involved in the neuro-humoral control of reproduction, when they found that strong electrical stimulation through the head might be followed by ovulation in the rabbit. Previously, Hinsey & Markee (1933) had suggested that a neuro-humoral substance might intervene between the hypothalamus and the anterior pituitary and so be involved in the liberation of gonadotrophic hormone necessary for ovulation. Since that time these possibilities have been considered in more detail and it has now been shown that more localised stimuli applied to various regions in the hypothalamus result in ovulation in the rabbit (Harris, 1948), whereas more localised lesions disturb gonadotrophic secretion. Furthermore, it has been suggested that the humoral stimulus to the anterior pituitary might be carried by hypophyseal portal vessels and the latter are, in consequence, believed to be intimately related to the maintenance and control of anterior pituitary activity.

a. *Blockade of Ovulation.*

Reflexogenic stimulation of the rabbit adenohypophysis leading to ovulation is apparently a rapid process which is completed within a short time after copulation. Fee & Parkes (1929) showed that, while hypophysectomy of the female rabbit (by decerebration) one hour after coitus would prevent ovulation, the same operation performed later than this had no such effect. The final link in the reflex is thought to involve an adrenergic neurohumour (Markee, Sawyer & Hollinshead, 1948; Sawyer, Markee & Everett, 1940), which is brought to the gland from the median eminence by the hypophyseal portal veins, alluded to above (Harris, 1948). The reflex can be blocked by the anti-adrenergic agent Dibenamine or its cogener SKF.501, when intravenous injection is completed within a minute after coitus (Sawyer, Markee, *et al.*, 1947; 1949; 1950). A cholinergic mechanism preceding the adrenergic one is assumed from the finding that intravenous injection of atropine will also usually prevent ovulation when injection begins within 15 seconds and ends 30 seconds *post coitum*. These observations have been extended to the cow by Hansel & Trimberger (1951); administration of atropine at the beginning of oestrus delayed ovulation for from 24 to 76 hours in four of five animals.

It must be pointed out, however, that, notwithstanding its attractiveness, the evidence in favour of an adrenergic transmitter being involved in the hypophyseal portal vessels as an excitant to pituitary activity has been questioned (Donovan & Harris, 1955). Likewise, Zuckerman (1954, 1955) and Thompson & Zuckerman (1955) insist that the integrity of the pituitary portal vessels is not essential for the reflex activation of the anterior pituitary, nor is it necessary to suppose that chemotransmitters are involved in the process.

Conclusions

In attempting to assess the significance of the foregoing data, we are embarrassed by the existence of much scattered but suggestive evidence and the lack of a unifying principle. We know, as did the ancients, that breeding seasons occur, but as yet we are still ignorant of the precise combination of factors that initiates the sexual rhythms of even a single vertebrate. The nearest we can approach the latter is to say that the seasonal maturation of the sex organs of various species must be viewed as a mosaic of events, the patterning of which depends upon an intimate and coalescent interaction of intrinsic and extrinsic factors. Surgical removal of the pituitary gland abolishes the normal seasonal cycle in many mammals and birds, and renders the gonads unable to respond to environmental factors which normally activate them. This indicates that the hypophysis is an essential link in the chain of

reactions which leads to sexual activation, but our understanding of the modes of action of the mechanisms by which changes in environmental temperature, light, food supply and social impact affect gonadal development remains an outstanding issue on which further research is urgently needed.

Summary

The reproductive cycles of vertebrate animals, while primarily under the control of the endocrine system, are greatly influenced by the external environment. The importance of environmental factors is indicated by the close correlation of reproductive function in many animals with the seasons of the year. The length of day and night, the exposure to artificial light and darkness and temperature are known to have important influences on the regularity of the oestrous cycle and sexual behaviour. The influence of light on gonadal development appears to depend on retinal stimulation and the effects of such stimulation upon the pituitary. The response elicited by light does not occur after hypophysectomy, and division of the optic nerves or removal of the eyes either prevents or greatly retards the reaction in mammals. Such observations suggest the existence of nervous connections between the eye and the pituitary, but the final common path within the organism remains controversial.

The sexual cycles are also under the influence of the higher centres and it is possible on this basis to divide animals roughly into two groups, those in which the C.N.S. exerts a marked measure of control and others where this is not apparent. In the former group, ovulation follows copulation or any intense nervous stimulation resembling coitus in its results; in the latter it occurs spontaneously. This control by the higher centres is also mediated through the pituitary and there is ample evidence that the nervous stimulus causes a sudden release of anterior pituitary hormones. This is shown by the fact that it can be artificially reproduced by the judicious use of gonadotrophic hormones.

The gonadotrophic hormones are the luteinising hormone (LH), the follicle stimulating hormone (FSH) and the luteotrophic hormone (LTH), which is responsible for prolonging the secretory life of the corpus luteum. Secretion of progesterone and the formation of luteal tissue are thus two distinct processes that can proceed independently. The luteinising hormone is responsible for the development of corpora lutea, and its co-operation with the follicle stimulating hormone is necessary to bring about ovulation. The appearance of LH in effective amounts initiates preovulatory swelling of the follicle, which is the first step in the process of luteinisation, during which ovulation usually, but not invariably, occurs. Also, the increase in the secretion of oestrogen incident to pre-ovulatory swelling is the result of the synergistic action of FSH and LH.

Oestrogen and progesterone are capable of inducing the characteristic behaviour patterns and copulatory reflexes associated with oestrus. Similarly, both ovarian steroids are involved in the ovulatory mechanism and are also required for full proliferation of the mammary gland. From these results it seems logical to conclude that the appearance of heat marks the beginning of luteal activity and the secretion of progesterone. It is noteworthy, however, that at this time luteal tissue as such has not yet appeared in the follicles, but certain early luteal changes have been detected in the follicular wall of pre-ovulatory follicles of the dog, and also of the cat, mouse, rat, mare and cow.

Female copulatory responses do not diminish following decortication in the rat, cat, guinea-pig and bitch, but the male's coital performance depends heavily upon the cortex of the brain and cannot be carried out in the absence of this part of the central nervous system.

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THE SPEAKER'S INTRODUCTION

The Chairman, Mr. E. Conn, opening the Session, said: "The subject of the paper is 'Hormone Control of the Oestrous Cycle' and that should prove of great interest to a very wide field of veterinarians. The author needs very little introduction: those of you who do not know him personally will have read about him and of his great contributions in the field of veterinary science.

"The opener of the discussion will be Mrs. Sheppard from Bayswater, London, a very distinguished practitioner who in her time has won practically all the medals that the London College has to offer."

Professor E. C. Amoroso (Royal Veterinary College): "No compliment could be more acceptable to me than being asked to participate in these discussions of your Association, yet the honour which this invitation conveys becomes less acceptable to me when I consider how varied are the qualifications that one must possess before addressing your distinguished Association. Nonetheless, I must confess that when your committee asked me to prepare a paper I accepted the invitation with the procrastinator's easy optimism and only when I came to write it did I realise how difficult was my task.

"I have presented a paper which deals with the morphology and control of the oestrous cycle and I have tried to portray in this paper the significant rôle the central nervous system plays in integrating the humoral responses which we associate with reproductive periodicity. In considering the paper we will, as is customary, take it as read. And we must leave it to the opener of this discussion to indicate the lines along which our discussion might be most profitable."

The Opener

Mrs. M. Sheppard (Bayswater): "We are all indebted to Professor Amoroso for presenting us with a paper of such excellent quality on a subject that is not as yet fully understood. His work will, I am sure, stimulate us to intelligent observation of the normal female animal in an attempt to be better able to interpret the abnormal sexual cycle when it occurs.

"I, for one, have been particularly impressed by the first part of the paper because for a long time I have been aware that abnormalities of the female sexual cycle—I am referring to the cat and bitch, the animals with which I am most conversant, and in fact my whole opening is on those two animals—could not always be explained by either primary hormone imbalance or disease of the sexual glands, and thus could not always be remedied merely by hormone injection. In many cases the cause lay much deeper or further back, possibly in the central nervous system or for some psychological reason.

"One must attempt to relate the manifestations of heat as one observes them to the influence of the sexual hormones that cultivate them.

"In the bitch pro-oestrus is marked by vaginal haemorrhage lasting for about seven days. In this stage, under the influence of the gonadotrophic hormone F.S.H., the graafian follicles are rapidly maturing in the ovary but ovulation has not yet occurred.

"During this period the bitch is not receptive to the male although to some degree attractive to him, and she will repulse with considerable violence any attention on his part. Oestrus or heat follows with the ripening of the follicles and ovulation. Here the dominant hormones are, first, oestrogen (during the follicular stage) and, later, progesterone (during the luteal phase).

"Physically, there is a marked swelling of the vulva, proliferation of the vaginal mucosa, and the uterus becomes enlarged, turgid—that is very important—and readily palpable through the abdominal wall, when it may be compared roughly to the size of a pencil and it can be readily rolled through the fingers in just the same way as a pencil can be rolled. Palpation of the ovary is not possible but the evidence seen at hysterectomy performed during heat shows the presence of a number of ripening follicles, small in size and scarcely protruding above the surface. Their rupture during heat leaves an almost imperceptible crater and, again, the corpus luteum, although raised above the general surface, is not large enough to distinguish by palpation. In other words, we are dependent upon examination of the uterus itself to find out whether the bitch is really in heat or not.

"During the luteal phase when progesterome becomes the dominant factor, uterine enlargement due to proliferation of the endometrium persists but the typical turgidity of the follicular stage is lost. The luteal phase is prolonged in the bitch where only one set of follicles ripen. This stage is quite easily discerned by palpation and can be differentiated from the early follicular stage. In the early stage you have a short, turgid uterus just like a pencil and in the later stage the uterus becomes more elongated in the abdominal cavity. It is still enlarged but it is very much softer and there is quite a difference in the feel of those two organs.

"Assuming that bitches mature in nine months and allowing pregnancy 63 days, it would be seen that most bitches have their heat periods at roughly the same time of year, that is, early spring and autumn, hence the occurrence in small-animal practice of the 'whelping season.' In other words, the heat coincides and so the whelping season coincides.

"To my mind, the cat presents a far more interesting, if less easily predictable, phenomenon, and it appears that much less is generally known about the sexual cycle of the queen than the bitch. The cat, a non-spontaneous ovulator, is in continuous heat, but a graph of the incidence of heat met through the year shows a peak period reached at the latter half of January to February. That is quite constant and very, very marked. Your queens will start calling not in spring, as is generally accepted, but early on in the year, January to February. This is most marked and constant, with a second peak about April to May, a marked drop in June rising again from August to September and dropping sharply from October until the next January.

"This may be influenced by the fact that a cat will show ripening follicles five weeks after parturition and will thus complete a breeding cycle in 14 weeks. If we allow for the anoestrus months, a queen, given her freedom, will produce three litters a year corresponding with the three peaks. In females prevented from breeding the greatest intensity of heat is also shown during these peak periods.

"The age at which a cat reaches sexual maturity is very variable. While seven months seems to be generally accepted, five months is not uncommon—in fact I would say rather more the rule than seven months—and I have met with the extreme precocity of a three weeks pregnancy in a four-month-old kitten. That was a kitten conceived early in the January peak, so she hit her season peak later on in the year and so became pregnant very early in her life. On the other hand, cats approaching maturity at the end of September will probably not show any signs of heat until the next January when they may be nine or ten months old or more.

"So, while we can accept that the pattern of the oestrous cycle is controlled by the hormones, these few but variable facts point the way that the hormones themselves must be subjected to still further control, possibly temperature and, to my mind, more important still, variation of light in duration and in intensity. During the dark days we have the period of anoestrus and as the light increases not only in length but in intensity we get the oestral period, with the typical three peaks.

"In the unmated cat the duration of heat varies from animal to animal, from three to ten days, with a period of 7 to 21 days before the return of heat. Each cat appears to have her individual cycle; that is, if a cat shows signs of heat lasting for three days with an interval of a week or 10 days, that period will recur corresponding to the peaks I have already mentioned, but even this is occasionally subject to variation in duration.

"The behaviour changes are equally well marked. During actual heat the bitch will seek her freedom at every opportunity and if she is given her freedom we will see quite a ritual courtship—it could even be described as a 'mating dance'—before mating actually occurs. That of course, does not occur where your bitch is mated, artificially or under control, but it is a constant factor where the bitch has her freedom. Change in behaviour is marked in the bitch as in the cat. In pro-oestrus, under the

influence of the anterior pituitary hormones, the animal becomes restless. During oestrus, or heat, she comes under the influence of the ovarian hormones and, as follicles ripen, oestrogen becomes dominant. The signs of this are that the cat continually throws herself to the ground and she rolls in a typical fashion and, like the rat, exhibits a marked lordosis. Her voice changes as well. It starts with a trill and, particularly in the Siamese, culminates in a raucous shriek, a noise which you would never hear from a cat in anoestrus.

"External physical changes in the cat are far less noticeable than in the bitch. The pre-oestral haemorrhage and vulval swelling is less pronounced and naturally of shorter duration than in the bitch, but abdominal palpation, which is remarkably easy in the cat—in fact you can easily palpate the uterus through the entire cycle—will reveal the short, turgid, enlarged uterus influenced by oestrogen followed by the still enlarged but flaccid progesterone stage It is in the cat that abdominal palpation will reveal this far more accurately than in the bitch. The cat has a thinner abdominal wall and considerably less abdominal fat and one can tell quite definitely under which hormones the cat is influenced; the turgid uterus under oestrogen and the flaccid, much larger and much longer uterus under the influence of progesterone.

"Pseudopregnancy does not appear unless as the result of a sterile mating or artificial stimulation of the cervix in the cat, but in the bitch, where the corpus luteum is functional, pseudopregnancy can be regarded as a natural occurrence. This is well recognised in racing greyhounds where bitches are rested during this period of pseudopregnancy. Of recent years this natural occurrence has reached pathological proportions and bi-annually an increasing number of bitches will come into heavy lactation, nest, exhibit bad temper if they are handled, and in one extreme case in my experience the bitch literally had labour pains. She simulated those until I called sharply to her when she stopped. How that occurred I have no idea at all and I would not have believed it unless I had seen it with my own eyes, but occur it did.

"Are we to conclude from this that the hormone output by itself is undergoing a change and that, except for the presence of a foetus, pseudopregnancy and pregnancy will eventually be indistinguishable? Or are we to seek the key to the problem in the central nervous system as it is affected by environment or some other extrinsic factor even if we do find the cure in the stilboestrol ampoule?

"This brings me to an aspect of the subject that one is usually a little diffident in bringing forward, but Professor Amoroso has himself set a precedent in discussing the influence of psychological factors upon the sexual hormone cycle.

"We have been given a most exact and lucid account of the actions and interactions of the anterior pituitary and of variant hormones in relation to the oestral cycle and we understand that the ripening of the follicles and ovulation is brought about by liberation of gonadotrophic hormones and that the anterior pituitary is under the control of the nervous centres, so it is not unreasonable to assume that psychological factors will have a profound effect on the sexual cycle and that this will be particularly apparent in the non-spontaneous ovulators where the higher centres exert the most marked measure of control.

"Here I would cite the cat as an example. With a queen allowed her freedom, it is the normal sequence of events that she mates during her heat and conceives. Such a natural coitus is preceded by a ritual courtship, the female attracting several males, watching the ensuing battles and finally mating with the victor.

"On the other hand, cats kept under breeding conditions, where they are confined during heat and in contact with only one male, often fail to conceive, heat returning according to the individual's normal cycle with no intervening pseudopregnancy. Therefore, the cat has not even ovulated. She is sent away to be mated, she is in full heat, she is mated but she fails to conceive and, therefore, presumably, she does not ovulate. Hence I am assuming that the male is fertile. It is well recognised that such animals, if allowed to mate naturally, would breed freely. The normal treatment for Siamese cats when one gets this condition of sterility during enforced mating is to let them out to select their own male and to let them go through the normal ritual of courtship and the normal stimulation of the central nervous system when the cat will ovulate and will breed.

"The conclusion to be drawn from this must be that, due to the absence of a sufficient titre of gonadotrophic hormones, ovulation has not taken place and that it is the psychological effect of the courtship and free coitus that is necessary for the efficient stimulation of the anterior pituitary enabling it to produce the proper stimulating hormone for the follicles to ripen in the ovary.

"The ritual of courtship, although observed in the bitch, does not bear the same relationship to fertility since ovulation is spontaneous, but it is an interesting supposition that absence of such a nervous stimulus might be responsible for the lack of luteinising hormone and progesterone with the subsequent failure to maintain pregnancy.

"We are aware that deficiency in one or more of the oestrus controlling hormones will disturb the normal cycle and is a potent cause of infertility due both to failure of ovulation and failure to maintain growth of the fertilised ovum. While we have available the four hormones necessary to make up such a deficiency, their empirical use is fraught with danger, and a very definite danger, too. One may upset the entire hormone balance by their injudicious use or by the use of the wrong hormone. It is very necessary that a careful investigation of both behaviour and physical changes observed during the sexual cycle should be made in order to assess which endogenous hormone is the deficiency which requires exogenous reinforcement.

"Thanks to Professor Amoroso, we are now in a much better position to be able to interpret the normal cycle and to understand what extraneous influences may alter the hormone output. I myself would not presume to discuss the hormone control in the sexual cycle of the larger animals but I do hope that others more qualified on this than I will carry on with the discussion"

Recent Advances in Poultry Therapeutics

BY

W. P. BLOUNT

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Introduction

THE choice of this subject is particularly apt, because we are now in a new era where disease control by therapeutics is concerned. It is a period which began with the outstanding work at Weybridge in 1942 which led to the control of caecal coccidiosis by sulphamezathine. Since that time other sulphonamides have been developed successfully, and more recently still we have had the "nitro" drugs. Superimposed on this picture has been the impact of the antibiotics, new anthelmintics and the use of aerosols for mite infestations. In one sense, therefore, to-day can be said to be among the brightest for the veterinarian, because there are now available more drugs with specific or semi-specific effects than ever before. Just tribute must be paid to the veterinary research workers at Weybridge, Lasswade, Houghton Grange, and to numerous commercial concerns, both here and in America, who have all been working for the welfare of the poultry industry in one way or another.

Although it is seldom economical to treat *individual* hens, no matter what the value of their pedigree, if diseases can be prevented or cured by the administration of specific drugs in the feed or drinking water of the *flock*, then such drugs and methods are invaluable to the farmer. How far it is economical for a veterinarian to indulge in poultry practice is, however, a matter which cannot be dealt with in general terms.

Unfortunately, many veterinarians have neglected poultry disease problems, partly because it has not been worth their while, but also because many of the poultry farmer's troubles are linked more with husbandry and nutrition than with pathology and bacteriology. Unless a practitioner is prepared to keep up to date on matters of avian physiology, dietetics, genetics and the influence of environment (particularly housing) on poultry *economics*, he probably stands little chance of maintaining the confidence of his poultry farmer clients who are often well versed in such matters due to the excellence of the specialist poultry press; and also by the many advisory leaflets published by the Ministry and other organisations.

The writer believes that many of the thousands of poultry *post-mortem* examinations which are conducted annually at various veterinary laboratories could be done by practitioners, if only they had the same confidence in their judgment which they would have were the work being carried out on a cow, horse, sheep, pig, cat or dog. I make no apology for stressing the fact that in my opinion many veterinarians have neglected poultry either because they could not see any worthwhile return from such work, or because they did not feel sufficiently competent to tackle the job.

Antibiotics

Although the influence of antibiotics on specific diseases has not been as marked in poultry as in some animals, this is probably because the effects of pyogenic organisms are seen less in the hen than in many other domestic animals.

Eleven years ago only two antibiotics were being used in medical practice, whereas to-day there are a dozen which could claim a place in veterinary medicine. New ones are being discovered every few months but the majority are either too toxic or unstable for clinical use. As each year passes, however, more safe antibiotics are available, and therefore, whenever possible, those with *specific* effects against particular poultry pathogens should perhaps be used, rather than placing too great a reliance on the non-specific effects of the so-called broad spectrum antibiotics.

Penicillin

Penicillin can be used for treating cases of streptococcal or staphylococcal arthritis, erysipelas and infectious sinusitis in turkeys, although for the latter disease it is more frequently employed in conjunction with dyhydrostreptomycin, *e.g.*, "Crystamycin"[1]. It has a specific effect against *Cl. botulinum*, and has been used successfully in Fowl Spirochaetosis and also in Goose Influenza (Exudative septicaemia).

Streptomycin

Streptomycin has been shown to have specific effects against some of the *Salmonellae*, and also for *Haemophilus* infections, as well as for combating Quail Disease and tuberculosis. There is also a record of its success in the treatment of aspergillosis.

Unfortunately, the ease with which streptomycin-resistant organisms develop, limits its application to poultry (as it does in other species), but even if it were effective (in conjunction say with iso-nicotinic acid hydrazide) for treating clinical cases of tuberculosis, it is very doubtful whether it would ever find a practical place in the industry. Presumably, were it to be used for other respiratory infections "Estomycin"[2] would be a particularly appropriate product since this focuses both penicillin and streptomycin to the respiratory tract. The adequacy of the dosage of streptomycin for *Haemophilus* infection in poultry was stressed to some purpose by Bornstein & Samberg (1953), who reported that 0.2 gr. (200,000 units) injected once intramuscularly yielded blood levels adequate for bactericidal effects against the majority of strains, but that dosages at lower levels would be likely to lead to the rapid development of resistant strains.

[1]Glaxo Ltd.
[2]Glaxo Ltd.

The Tetracyclines

The first antibiotic in this series "Aureomycin,"[3] was quickly followed by "Terramycin,"[4] their discoveries being quite independent. Later the chemical composition of aureomycin was found to be chlor-tetracycline and similarly that of terramycin oxy-tetracycline. Although these can be seen to be very similar indeed, the parent substance, tetracycline was not discovered, or used, as a separate antibiotic until several years later (1953). Now all three antibiotics are available (in the U.S.A.) and it is of interest to note that aureomycin and terramycin are sometimes *not* interchangeable, and that under certain conditions tetracycline also has its own independent anti-bacterial action. (Welsh, 1954).

Both aureomycin and terramycin are recommended for helping to combat outbreaks of infectious sinusitis and "Blue Comb" in turkeys, and also chronic respiratory disease in chickens. They have also been used for treating outbreaks of hexamitiasis and for reducing the mortality which sometimes appears in very young chicks or poults. There are also reports of the successful use of aureomycin and terramycin against fowl cholera and salmonella, but in this latter group of infections, and for B.W.D. and fowl typhoid in particular, the emphasis to-day is on the use of furazolidone rather than on any antibiotic.

Chloramphenicol

"Chloromycetin"[5] is not used a great deal in the poultry industry, presumably because it is not very satisfactory for inclusion in feeds for controlling infections of the lower bowel owing to its rapid absorption from the duodenum. It can, however, be recommended for treating cases of fowl cholera, and as a supplement to terramycin it might also be tried out in C.R.D. infections.

Other Antibiotics

Although there are several records of the value of bacitracin, erythromycin, neomycin, magnamycin, polymyxin and others for controlling certain pathogenic organisms which attack poultry, these are not being discussed for various reasons.

Condition for which antibiotics are indicated

Aspergillosis

Mantovani & Airoldi (1952) were able to effect a marked reduction in the number of deaths in fowls suffering from aspergillosis by injecting them with 50 mg. of dihydrostreptomycin in a procaine-pectin vehicle once daily, but this work has not been confirmed.

"Blue Comb" (Turkeys)

Although pullet disease in chickens is sometimes called "Blue Comb" this same term is now being used extensively in America to describe a non-specific, catarrhal enteritis of turkeys characterised by watery droppings. This highly infectious condition can be reproduced experimentally, but the causal agents have not yet been clearly identified although salmonellae and hexamita have been incriminated. Aureomycin, penicillin, streptomycin and terramycin have all proved of some value in the control of this disease, at high level dosages in the feed (500 grammes per ton) or in the drinking water, *e.g.*, 1 gramme streptomycin sulphate in 1 gallon.

There is some doubt as to how far "Blue Comb" disease affects turkeys in this country.

Botulism

Penicillin was shown by Anderson *et al* (1953) to be the best of 10 antibiotics tested against *Cl. botulinum*, but there would appear to be little opportunity for its use in this connection in Britain as botulism is so rarely encountered.

Chronic Respiratory Disease (C.R.D.) of Chickens

The chief symptoms of this insidious disease are râles, coughing and sneezing, but many cases appear almost symptomless and only show *post-mortem* features, *i.e.*, pustular involvement of the infra-orbital sinuses, lungs or air sacs.

Aureomycin given as a feed supplement (50 to 400 grammes per ton) was shown by White, Stevens & Zebiel (1953) to be highly effective in maintaining the appetite and efficiency of feed utilisation in such cases. The growth rate of treated stock was distinctly superior to that of unmedicated controls, and in some of their experiments there was also a significant reduction in mortality. Successful treatment by 50 mg. of terramycin, suspended in mineral oil, injected subcutaneously at the base of the comb has been described by Carson *et al* (1953). The symptoms had largely disappeared by the sixth day after injection and no recurrence took place: the shorter the time the disease had been present, the greater the response to treatment. Against these findings Cover (1954) found that a variety of antibiotics did little to decrease the mortality in flocks of laying pullets (totalling 18,300 birds) affected by C.R.D.

Coryza

Although neutral sodium sulphathiazole ("Avisol")[6] is successful in dealing with many outbreaks of colds, a few residual cases often persist. These may be treated successfully by local applications to the *nares* of penicillin, streptomycin or a combination of both. (Archibald, 1954).

Erysipelas

For the prevention of erysipelas in turkeys Hamilton (1953) found that an injection of 200,000 units of D.B.E.D. ("Bicillin")[7], per bird gave complete protection from experimental infection up to 48 hours, and in some cases up to four days. A single dose of 200,000 units also proved efficacious for treating infected turkeys, providing this was given in the early stages of the disease. Botorrf (1955)

[3]Lederle Laboratories Ltd.
[4]Pfizer Ltd.
[5]Parke Davis Ltd.
[6]May & Baker Ltd.

recommends 100,000 to 200,000 units of penicillin in conjunction with an erysipelas bacterin.

Exudative Septicaemia (Geese)

Penicillin has been used successfully for the treatment of exudative septicaemia in geese in conjunction with sulphathiazole (Gerriets, 1953). German research workers have isolated gram-negative organisms from such cases of "goose influenza," variously described as *B. septicaemiae anserum exudativae*, *Shigella septicaemiae* and *Haemophilus* spp.

Fowl Spirochaetosis

In many parts of the world (Central and Eastern Europe, Russia, Asia, India, Australia, Africa, Brazil) fowl spirochaetosis, which affects chickens, geese, turkeys and ducks is of considerable importance. Diagnosis depends upon the demonstration of the causal spirachaetes and although specific therapy with various organic arsenical preparations has been succcessful in the past, penicillin has also been shown to be highly effective, the dose being 20,000 units per kg. (Balintffy, 1951).

Infectious Sinusitis

The causal agent has been shown by Groupe & Winn (1949) to be susceptible to both aureomycin and streptomycin, but not to penicillin or sulphadiazine. Terramycin and chloromycetin have also been shown to exert an inhibitory effect, but of 16 antibiotics examined *in ovo* for activity against the causal agents common to infectious sinusitis (turkeys) and chronic respiratory disease (chickens) magnamycin was found to be the most effective antibiotic.

Gross (1953) showed that terramycin in *oil* was about eight times as effective for treating cases of infectious sinusitis as either terramycin or streptomycin in *water*. Zander (1955) recommends 100 mg. streptomycin per 5 lb. bodyweight together with aureomycin or terramycin in the feed (100 to 300 grammes per ton). Wilson (1954) has recommended a combination of 100 mg. streptomycin, 100,000 units of penicillin and two c.c. of saline injected into the affected sinuses, but up to four times the dosage of streptomycin may be given intramuscularly for three or four days whenever serious symptoms are present. There is little doubt however, in practice, that one requires to switch from one treatment to another, as soon as the former ceases to be effective; aureomycin, streptomycin and terramycin being used, with penicillin included only for its synergistic effects. No matter how apparently successful one's treatment, "carriers" are probably always left behind, and de-population should be carried out whenever practicable.

Non-Specific Infections

The value of penicillin for controlling non-specific infections, in young turkey poults for example, is well seen in the experiments of Harper & Babcock (1953); and particularly interesting was the fact that when given orally (200 micrograms per poult) penicillin was not as effective as when given *continuously* in the feed (4 grammes per ton). Their local conditions, however, must have been somewhat unhygienic (or the stock very debilitated) because 55 out of 120 control birds died, compared with 14 in the penicillin fed groups. At this early age one would not expect mortality to exceed 5 per cent. unless some specific disease were present, *e.g.*, coccidiosis or blackhead.

Pullet Disease (Chickens)

Various attempts have been made to use antibiotics for dealing with Pullet Disease (Avian monocytosis) but all have failed. One such typical result is that of Adler *et al* (1952) who used aureomycin in the feed (100 p.p.m) and also by oral administration (100 mg.) but even this did not lower the mortality rate. High level feeding (200 to 1,000 grammes per ton) using aureomycin or terramycin might, however, have given a better result in conjunction with molassed (1 per cent.) drinking water.

Quail Disease

The efficacy and ease of administration of streptomycin in the feed or water for the treatment of ulcerative enteritis in Bobwhite quail (Quail Disease) has been confirmed many times in America, as little as 1.75 grammes of streptomycin calcium chloride to each gallon of drinking water being effective (Kirkpatrick *et al*, 1953).

Staphylococcal Arthritis in Turkey Poults

This condition due to *M. pyogenes var aureus* has long been recognised as a specific entity in poultry. Symptoms are lameness, a hobbling gait, swollen joints, loss of appetite and eventually emaciation. Some relationship between the spread of this disease and mosquitoes apparently exisits, and in certain cases it apparently results from incubator contamination.

Terramycin promises to be of value, particularly when any penicillin-resistant staphylococci are present. In an outbreak described by Fahey last year, affecting over 800 10-day-old turkey poults, an antibiotic mixture comprising 2 mg. terramycin, 2 mg. di-hydrostreptomycin and 10,000 units of potassium penicillin was used successfully; terramycin feed supplement was also given for seven days (200 grammes per ton). A study of the sensitivities of the different germs (isolated from the poults at 21 days of age) to various antibiotics resulted in the following order of preference: terramycin, chloromycetin, aureomycin, bacitracin, streptomycin and penicillin. Mortality at the time of treatment was 17.3 per cent., but within three days the general condition and appetite of the turkeys had improved, and within two weeks the disease had disappeared. There had been no recurrence three months later: the total mortality, following treatment, was 2.1 per cent.

In this outbreak another organism *Proteus mirabilis* was also shown to be pathogenic for turkey poults, but terramycin was found to be equally efficacious.

[7]Wyeth Ltd.

Antibiotic feed supplements

The modern cult of including antibiotics in poultry feeds began soon after Jukes's announcement from Lederle Laboratories (U.S.A.) in 1948 that an aureomycin supplement included at very low levels stimulated chick growth in excess of that which might have been expected from its complement of vitamin B12. In this country we were not permitted to include procaine penicillin or aureomycin in poultry feeds until 1953 nor was permission given to incorporate terramycin until a year later. The present permitted levels are from 4 to 100 grammes per ton, but the following are commonly used:—penicillin 4 to 5 grammes per ton; aureomycin and terramycin 7½ to 10 grammes per ton. At one time it was believed that a growth stimulus effect would not result unless (a) the diet consisted only of vegetable proteins, or (b) the chicks environment was unhygienic. It was soon shown, however, when good conditions existed and when the diet contained from 5 to 7 per cent. of animal protein that a 10 per cent. increase in body weight might result, as well as a 5 per cent. improvement in feed conversion. Once antibiotics are incorporated into mixed feeds they are often unstable, particularly if certain trace minerals or undue moisture are present, therefore an "overage" is necessary to counterbalance losses from these or other causes.

High level dosage

The Americans also first practised the "high-level" use of antibiotic feed supplements, including them at such a rate that they would supply from 50 to 1,000 grammes of antibiotic per ton of feed. This was done to counteract (a) sub-clinical infections (generally of unknown origin) or (b) other biological stress factors, for which there was an equally uncertain cause in the majority of instances.

Egg Production

Here is a typical example using terramycin when egg production had fallen to an uneconomic level due to no obvious cause. The egg production of the 5,000 breeding stock concerned had fallen from 50 per cent. to 20 per cent. for no accountable reason. *Post-mortem* reports from two laboratories were negative, but a third indicated the presence of a sub-acute infection of the infra-orbital sinuses (?C.R.D.). Twenty-six days after commencing "high-level" treatment with terramycin, egg production had risen from 21.3 per cent. to 56.4 per cent., the breeder being able to incubate 8,500 more eggs during the third week of treatment than he did during the week before treatment commenced.

This may not be the sort of result to impress a research worker because no untreated birds were kept, but the farmer was particularly delighted because by spending less than £1 a day on the antibiotic feed supplement he obtained a daily average of £84 worth more eggs.

Treatment comprised soluble terramycin (½ oz. per 2 gallons) in the drinking water for two days, followed by 75 grammes per ton in the feed for four days and then 15 grammes per ton for 28 days.

When antibiotic feed supplements used at *low*-levels are effective in raising egg production in pullets this *may* be due to an initial shortage of vitamin B12 in the ration; but when there is a response at *high*-level dosages this is more probably due to an effect on their health rather than on their nutrition.

Hexamitiasis

Although terramycin feed supplement (100 gr. per ton) has been recommended for helping to control the ravages of hexamitiasis it is probable that a combination of this (or aureomycin) with furazolidone represents by far the best line of treatment.

Roundheart Disease

The incidence of this unusual disease in fowls is increasing, particularly in pullets housed on deep-litter. Its aetiology is still uncertain and although the characteristic cardiac condition may be related to a chronic infection, few British investigators will agree with Guerden (1951) that *S. pullorum* is likely to be involved. This is surely a disease, however, where antibiotic feed supplements might reasonably be expected to play a useful part if given continuously in the feed at a moderately high level—*e.g.*, 50 gr. or more per ton.

Whilst the *modus operandi* of antibiotics given *continuously* in the feed is still uncertain it can be assumed to be due to effects on the micro-flora of the intestines since Reyniers (1953) has shown that when chicks are reared in a completely germ-free environment they do not respond to antibiotic supplemented feeds. There have been many attempts to explain the action of antibiotics—relative to their effects on the bacterial and fungal flora of the intestines—but the real answer has still to be found.

The Sulphonamides and Coccidiosis

Coccidiosis in Chickens

Whilst sulphaguanidine proved early on to be quite a useful preventive for caecal coccidiosis if given before infection took place (Levine, 1951), and although both sulphamerazine (Swales, 1944), and sulphadiazine (Horton Smith, 1948) have given good results experimentally, it is to sulphamethazine and sulphaquinoxaline that we turn to-day for the most economical results for controlling this disease when using the sulphonamides. One can say in fact that all other "sulpha" drugs have now been discarded.

Sulphamethazine

An 0.2 per cent. solution of sulphamethazine ("sulphamezathine") is commonly given in the drinking water for three days, miss two days, give three days; this routine having now been shown to be the best (Davies & Kendal, 1954). In practice one adds 2 oz. of a 16 per cent. solution of sodium "Sulphamezathine" to one gallon of drinking water, care being taken to see that the birds do not have access to any other fluid.

Sulphaquinoxaline

Possibly because of an impression that sulphamethazine was sometimes unpalatable to chicks, and also because sulphaquinoxaline had gained a reputation in America for being the better drug for dealing with "intestinal" as well as caecal coccidiosis, sulphaquinoxaline first came into prominence in Britain in June, 1951; and for such therapy 2 fl. oz. of "Embazin" are now added to three gallons of drinking water.

Although both Kendall (1950) and Horton Smith (1951) showed sulphaquinoxaline to be superior to sulphamethazine as a coccidiastic agent under certain circumstances, little experimental work has been published to show the comparative value of these two drugs for dealing with "mixed" intestinal infestations, and there are doubtless strong adherents in the farming industry to both products.

Both drugs can also be given in the feed, Kendall & Davies (1952) having shown that 0.25 per cent. sulphamethazine given in this way has a selective effect on second generation schizonts, but the more common practice is to use low level sulphaquinoxaline (0.0125 per cent.) continuously as a preventive rather than the higher dosage (in the feed) for curative purposes.

Coccidiosis in Turkeys

The treatment of coccidiosis in turkey poults is a subject about which much still requires to be known, new species having been discovered during the past year or so and their response to the sulpha drugs is uncertain. But Horton Smith (1954) feels inclined to recommend 0.0125 per cent. sulphaquinoxaline in the feed as a preventive since this seems to meet experimental infections efficiently. Sulphamethazine may be equally efficient if it proves palatable to young turkey poults, these, however, appear to be more fastidious than chickens in their feeding and drinking habits.

Coccidiosis in Geese

The writer has not had any personal experience of the use of the sulphonamides against renal coccidiosis in geese or swans, and any results practitioners may have had would be of great interest and value.

The continued use of the sulpha drugs in both this country and America naturally makes one wonder whether or not drug-fast strains of coccidia have been, or are likely to develop. This subject was recently studied by Harwood & Stunz (1953) who found that three newly isolated strains in America were fully susceptible to both nitrofurazone and sulphaquinoxaline; and there is presumably no field evidence which contradicts that result in Britain.

Other treatments for Coccidiosis

Some years ago the bisphenols were being tried out with apparent success (Groschke *et al.* 1929) which was confirmed by Hawkins & Dunlap (1949), but very little has been heard of them since then. Gresev & Koptev (1953) reported from Moscow that trypanblue (0.12 per cent. for seven days) was highly successful in controlling the mortality from coccidiosis. Rossi & Prandi (1953) found that 5 7-dichloro-8-oxyquinaldine given in the food (20 mg. per bird) also reduced the mortality from coccidiosis, whilst a new coccidiostat "Ni-carbazin"[8] (used at a level of 0.125 per cent.) is also receiving considerable publicity in America having been specially designed for combating coccidiosis in young chickens.

Toxic effects of Sulpha drugs

Gordon (1951) first drew attention in this country to a new haemorrhagic syndrome which was associated with the use of sulphaquinoxaline; since that time many outbreaks of so-called "haemorrhagic disease" have occurred (we have had four ourselves), but the actual relationship between these and the sulpha drugs is still not yet clear. There can be no question, however, that the losses concerned may occur when sulpha drugs have been used at perfectly normal levels, on the 3 : 2 : 3 day basis. Mortality, however, need not be very high, and there is now clear evidence that some strains and breeds are much more susceptible to the malady than others. In America it has often been assumed that the haemorrhages may be related to a deficiency of vitamin K, but since they have occurred in this country in pullets in movable folds, on a diet already containing dried grass meal, it appears probable that so-called sulphonamide poisoning is not related primarily to any avitaminosis-K. As the syndrome often includes nephritis it is necessary to ensure an adequate water intake and if 1 per cent. molasses is added to the drinking water this will be found to be effective.

The "Nitro" drugs

One of the first drugs in this series to be used extensively by the poultry industry was nitrophenide which was first marketed in the U.S.A. in 1949 by Lederle Laboratories as *Megasul*, a 25 per cent. pre-mix. At that time the sulphonamides were being used generally and it was of considerable interest, therefore, to see whether nitrophenide's impact would be temporary or permanent.

This was followed by the "nitrofurans" of which nitrofurazone is the best-known example, this having been introduced in 1952 for the control of coccidiosis. Last year, however, furazolidone also became available, and as this drug exerts direct effects against salmonella infections (as well as against Histomonas and Hexamita) its potentialities are very great indeed. *The Nitrofurans in Veterinary Medicine*, a little booklet recently published by A. J. White, Ltd., will be found by practitioners to be of great use to them.

Nitrophenide (m, m^1 - dinitro-diphenyl-disulphide) is recommended in America for controlling both caecal and necatrix coccidiosis, it being the most

[8] Merck Ltd.

promising of some 2,000 compounds screened for activity against *E. tenella* infestations. (Waletsky, Hughes & Brandt, 1949). Its activity was 10 times that of sulphaguanidine, and where 60 per cent. of the untreated controls died, there was no mortality amongst those receiving 0.05 per cent. nitrophenide in their feed.

Limited supplies of *Megasul*[9] have generously been made available by the manufacturers for experimental purposes, but as its normal importation from America would require dollars, additional supplies have been obtained from Holland where pure nitrophenide is available as *Dagiasol*[10].

We have used nitrophenide successfully in dealing with several outbreaks of intestinal coccidiosis, particularly when given in conjunction with aureomycin, their respective levels being:—nitrophenide 0.025 per cent.; Aurofac 2A 10 lb. per ton.

Here is a typical example. A well-known accredited poultry breeder whose rearing results had been getting steadily worse during the past two years discovered last season that over 200 of his pedigree R.I.R. pullets had died before coming into lay. He had been following an inbreeding programme and had assumed that his losses were due to this, but in view of the disastrous results mentioned he felt that he must finally consult an authority, even at the risk of losing his accredited status!

Dead pullets examined in 1953 showed a fairly consistent *post-mortem* picture, mainly intestinal coccidiosis but complicated by fowl paralysis and nephritis; odd birds also showed infestations with ascaridia. The first dozen birds examined in 1954 all showed heavy infestations with duodenal coccidia and so the farmer supplemented his growers ration for the remainder of the season with nitrophenide. It was obvious that the results were satisfactory from the farmer's point of view because he insisted on using only medicated rations this year—nitrofurazone for the first six weeks, and nitrophenide from then on to point-of-lay. His losses this year have been reduced by nearly 75 per cent. and duodenal coccidiosis has been completely absent; the majority of the deaths being associated with the fowl paralysis complex.

Toxic effects of Nitrophenide

Dagiasol consists of pure nitrophenide whereas *Megasul* is a pre-mix containing 25 per cent. of nitrophenide, therefore the former product contains four times as much of the active principle as the latter. This point was recently stressed to some purpose when a poultry farmer in the Midlands gave his 14-week-old growing chickens a mash containing 2¼ lb. per ton of pure nitrophenide, *i.e.*, a level of 0.1 per cent. (The levels of nitrophenide normally recommended lie between 0.025 per cent. and 0.04 per cent.). Four days after the feed had been given nearly all the pullets were showing nervous symptoms, which the owner thought might represent "epidemic tremors." Food consumption fell by nearly 40 per cent. and although only a small number of pullets were "off their legs" more than 1,000 were "staggery" if compelled to move about. For no apparent reason some would suddenly rush off blindly and leap into the air as though jerked up with a piece of string. Mortality was nil.

From the sudden onset, mass nature of the attack and general history of the case as described over the telephone a tentative diagnosis of nitrophenide poisoning was given and the feed was immediately changed to an ordinary growers ration. Within 48 hours nearly all the pullets were perfectly normal again and six weeks later a number were starting to come into lay. A sample of the suspect feed was received and found to reproduce the same symptoms within a period of three days when fed to six-week-old cockerels.

Nitrofurazone

Although nitrofurazone is included in the drugs listed in the *British Veterinary Codex* 1953, data concerning its use for the control of coccidiosis at that time were very limited, as it had only been introduced into this country the year previously. Since that time, however, several proprietary brands (*Nefco*,[11] *N.F.Z.*[12] and *Chixin*[13]) have been used extensively, either in the feed or drinking water, at both preventive and curative levels.

The action of nitrofurazone is considered by Horton Smith & Long (1952) to be both schizontistatic and schizonticidal; the drug permitting the normal development of immunity in chicks exposed to infections by *E. tenella* during treatment.

Nitrofurazone as a Preventive of Coccidiosis

In dealing with coccidiosis there are two schools of thought, (i) wait for the disease to develop and then treat it; and (ii) attempt its prevention by low level medication in the feed. For the latter method nitrofurazone has been the drug of choice for many farmers, but the level of inclusion has varied from 0.005 per cent. to 0.01 per cent.

Last year we supplied sufficient medicated chick feed for treating at least 1,000,000 table birds at the 0.005 per cent. preventive level, and although one obviously had no accurate guide as to its efficiency, if the number of complaints about its ineffectiveness are any indication of its worth it did a very good job indeed!

This year on an even larger number of chicks we have used nitrofurazone at the 0.01 per cent. level—some authorities not believing that it could possibly act as an efficient coccidiostatic at the weaker strength (0.005 per cent.)! So far, however, there appears to be no greater benefit from doubling the dose in this manner, but what we can say is that it does not make the feed unpalatable nor does it interfere with the growth rate even when fed continuously for 18 weeks. This supports Gordon, Chubb & Stacey's (1953) finding that 0.011 per cent. nitrofurazone could be fed continuously for 16 weeks to pullets without detriment to their bodyweight gain. But even this higher level does not prevent all outbreaks of coccidiosis. Nevertheless, it is invaluable to the poultryman because it relieves

[9] Lederle Laboratories Ltd.
[10] Dagra Ltd.
[11] A. J. White.
[12] Cooper's.
[13] I.C.I.

him of one of his chief dreads, and it seldom lets him down, so long as he does not forget completely his hygienic arrangements, *e.g.*, by failing to change the litter over a period of several successive weeks.

Last year we organised certain Table Poultry Feeding Trials which took place on 136 farms scattered throughout the whole country. The number of chicks involved was 8,500 and the feed medicated with 0.005 per cent. nitrofurazone was given throughout to 12 weeks of age when the birds were killed. Their average weight was 4 lb. 4.27 oz., their feed conversion 3.28 and their mortality from all causes was only 2.34 per cent. All chicks which died were subjected to *post-mortem* and coccidiosis was found to account for only 12 deaths (0.14 per cent. mortality).

The inclusion of nitrofurazone in the feed continuously at low levels appears, therefore, to represent a cheap and practical safeguard against caecal coccidiosis, but we have not quite the same confidence in its effectiveness against outbreaks of duodenal coccidiosis, nor against coccidiosis in turkeys.

As nitrofurazone may have a depressing effect on some of the intestinal bacteria—Lannek & Bragg (1954) having shown that it could be used as a prophylactic against *S. choleraesuis* infection in pigs—the suggestion has been made that to use it continuously in the feed for chickens may predispose to a vitamin B deficiency, particularly that of riboflavin. Indeed Harwood & Stunz (1950) did find in some of their experiments that some of the chicks showed signs of curly toe paralysis, but so did 13 per cent. of their controls! A statistical analysis of their results indicated that nitrofurazone at 0.0067 per cent. may have caused "a slight exacerbation of the dietary deficiency." In our various trials at Stoke Mandeville we have been using normal chick feeds containing approximately 3.5 grammes per ton of riboflavin and have never experienced any similar cases of vitamin B2 deficiency.

Nitrofurazone for Curative Purposes

When given in the feed at four times the low level dosage, *i.e.*, 0.02 per cent. for seven days, nitrofurazone is valuable as a curative for caecal coccidiosis. A water soluble form ("Nefco Soluble"[14]) is particularly useful, because when given in the drinking water (as opposed to the feed) the level of inclusion can be reduced by half to 0.01 per cent.

One particular virtue of nitrofurazone for coccidiosis in chickens is the absence of "haemorrhagic" complications, no matter at what level it is used.

Toxic Effects of Nitrofurazone

By a curious mischance at the beginning of this year a batch of three- to six-week-old chicks was given nitrofurazone at a level of 0.1 per cent. in the feed instead of 0.01 per cent.; deaths began to occur about 10 days later, but the *post-mortem* findings were inconclusive. Although about 60 per cent. of the chicks died in this manner, within a three to four week period, there was little to indicate to the veterinary surgeons concerned the cause of the trouble.

The symptoms, however, became quite characteristic, the chicks would stand silently under the hover, motionless, bedraggled, rough feathered and almost completely devoid of interest in either food or drink. Each morning a few more cockerels would be found dead, but throughout the whole period the *post-mortem* findings remained atypical—patchy enteritis and cardiac degeneration being the only features of note. At this stage a special investigation was carried out at the farm, and the fatal mistake mentioned earlier was revealed. As soon as the remaining chicks were given non-medicated mash, deaths ceased and they gradually recovered normal appetites. To clinch the diagnosis a group of healthy six-week-old chicks was given the baby chick mash (containing 0.1 per cent. nitrofurazone), and within two weeks nearly all had died showing the same symptoms and *post-mortem* findings.

A simple mistake of this kind could easily occur if an error in mixing were to take place at any centres where medicated feeds were being prepared.

Jordan (1955) has also described accidental nitrofurazone poisoning, in baby chicks aged less than seven days which, however, had been subjected to a prolonged rail journey in very cold weather and some chicks were dead on arrival. A number showed inappetence and marked depression (presumably not unlike that which we experienced in older birds) but a small number also showed symptoms of hyperexcitability "dashing about madly, whirling in circles, flapping and jumping about like decapitated birds." These are the symptoms which we found in nitrophenide poisoning (in growing pullets) but without the heavy mortality experienced by Jordan.

Furazolidone

(N-5-nitro-2-furfurylidene-3-amino-2-oxazolidone)

Salmonella Infections

The efficiency of furazolidone in controlling the mortality in typhoid of *S. gallinarum* origin in turkeys was described by Grumbles *et al* (1954), this paper soon being followed by others dealing with researches at the Animal Health Trust. Williams Smith (1954) reported on its special value in experimental fowl typhoid, as did also Harwood & Stunz (1954), but the particular value of the former work was the greater effectiveness in using the drug at an 0.04 per cent. level—twice that used in America. This was followed by an equally outstanding paper by Gordon & Tucker (1955) who showed that when furazolidone was fed continuously for 10 days in the feed 11 out of 13 birds formerly positive to the blood agglutination test for B.W.D. were subsequently found to be free of *S. pullorum* infection. Furthermore, when given at a 0.04 per cent. level, seven out of eight birds became negative to the agglutination test 60 to 84 days after the termination of the 10 day treatment. Thus, for the first time, we appeared to possess a drug which would provide the farmer with an added insurance (to that of the blood test) against the risk of pullorum disease.

Previously, some of the sulphonamides, particularly sulphaquinoxaline and sulphamerazine, had been shown to be of value in reducing the mortality

[14] A. J. White Ltd.

from B.W.D. infections in chicks (Severens, Roberts & Card 1945), but no drug had been discovered which would "sterilise" an infected bloodstream or ovary.

Our own experience with furazolidone in chicks has been limited to two outbreaks of *S. thompson* infection involving 700 heavy breed hybrids five days old. Thirteen chicks died before the bacteriological examination confirmed the diagnosis, yet the total mortality was only 2.42 per cent., the last death occurring on the 14th day. The survivor cockerels at eight weeks of age weighed 1 lb. 15 oz. so that in this instance at least furazolidone proved practical and economical. Mortality from all causes was 7.52 per cent.

Blackhead and Hexamitiasis

Furazolidone has also been recommended for the control of blackhead in turkeys, but there do not as yet appear to be many records of its efficacy, whereas for dealing with hexamita infection it appears to be the drug of choice. Last year, for example, a farmer in the Midlands lost 500 out of 1,000 growing turkeys before trying out furazolidone. His losses had been diagnosed variously but coccidiosis was prominent, and treatment with sulphaquinoxaline and other drugs had been given but had not stemmed the losses which continued throughout the rearing season. When hexamitiasis was suspected three groups of poults were treated with "Entramin," "Megasul" and "Neftin" respectively and within 48 hours losses ceased in the group receiving furazolidone, whereas deaths continued in the other two groups.

An outbreak in a nutrition experiment at the poultry department of Texas A. and M. college in the summer of 1953 was successfully controlled using furazolidone at a level of 100 grammes per ton. The following year in a further series of experiments Professor J. R. Couch (1955) and his colleagues confirmed that when treatment was began two days prior to inoculation with *Hexamita* (or simultaneously with the inoculation), mortality was as low as 10 to 13 per cent. whereas it was from 52 to 66 per cent. in the controls. (*Note*: Dibutytin duaurate ("Tinostat") is also being used successfully in the U.S.A. for treating outbreaks of hexamitiasis.).

Dosages

For *continuous* feeding purposes the Americans recommend a level of 0.011 per cent. for the prevention of blackhead, hexamitiasis and salmonella infections (typhoid, paratyphoid and pullorum); and for *curative* purposes from 0.0165 per cent. to 0.033 per cent. Tablets containing 50 mg. are also recommended for individual dosing purposes. Results from the Animal Health Trust, however, favour a 10 day curative treatment at the 0.04 per cent. level.

Amino-Nitrothiazole

The introduction of amino-nitrothiazole compounds in 1950, following McGregor's experiments reported a year earlier, quickly changed the outlook on the curative therapy of blackhead, because up to that point there had been no really specific product available although certain organic arsenicals in trivalent form had proved useful.

The original product 2-amino-5-nitrothiazole (Enheptin-T) quickly took hold in the U.S.A. and with the introduction of *"Entramin"*[15] in this country we too benefited enormously. This year however has seen a possible change because the acetylated form *"Enheptin-A"* (2-acetylamino-5-nitrothiazole), is cheaper to produce and equally satisfactory in use and is now being popularised in America. Incidentally, Brander & Wood (1955) have recorded that the acetylated drug given for several months to cock and hen turkeys did not affect either their fertility or hatchability results. Owing to some peculiarity in our tax regulations, however, blackhead preparations containing this product can only be sold with purchase tax added, whereas the 2-amino-nitrothiazole preparations are sold tax free! We can assume however that a cheaper than "2-amino" equivalent of *"Enheptin-A"* will shortly be available which will prove a great boon from the cost angle, because all such preparations *must* be given continuously if blackhead is to be prevented. There is some evidence to suggest that these products have an anti-Heterakis as well as a histomonocidal action (Swales, W. E. 1950) and therefore their therapeutic attack is twofold.

In a recent talk given by D. L. Hughes (1955) stress was laid on the fact that for preventive purposes the level of inclusion of "2-amino" is 0.05 per cent. (given in the feed continuously), and for curative purposes 0.1 per cent. for 14 days followed by 0.05 per cent. thereafter. If less is given relapses may occur and if the preventive level is not used, following the curative dose, later deaths may occur because *no immunity develops*. Amino-nitrothiazole in water soluble form is also available and equally effective and there are also capsules of the drug (100 mg.) available for treating individual birds; but these should *not* be given on an empty stomach.*

This same series of drugs is equally suitable for treating chickens, game and other birds, but the risk of nephritis in young birds may sometimes be of importance. Following 14 days' treatment at the curative level to four-week-old poults last year at one of our farms, 10 per cent. of the birds died from nephritis. This was later found to be associated with an inadequate intake of water—a point which therefore requires to be watched carefully.

Other treatments for Blackhead

Acetarsol is being used successfully as a preventive for blackhead, the soluble sodium compound being given continuously in the drinking water (Hughes 1955). In like manner *4-nitrobenzene arsonic acid* (McGregor & Morehouse 1952) included in the feed at an 0.0125 per cent. level is commonly employed in the U.S.A. *Hydroxyquinoline* compounds are also being used in America, the two chief preparations being "Vioform" and "Clioform"; and the *nitrofurans* have also been used successfully for controlling experimental infections (McGregor 1953). See also Horton-Smith & Long (1955).

* Nor to turkeys under 3 lb. *e.g.* six to eight weeks old.

[15] May & Baker Ltd.

Anthelmintics

Gapeworms

The modern intensive methods of rearing chicks to eight weeks of age have almost completely eliminated gapeworms *(Syngamus trachealis)*, but when trouble does arise barium antimonyl tartrate[16] is the drug of choice. It can be used for all classes of poultry and is given by insufflation, but the difficulty of handling partridge and pheasant chicks when debilitated by gapeworms is a point to be watched (Clapham 1955).

Tapeworms

Heavy infestations with the minute tapeworm *Davainea*, so common in pre-war days, are seldom seen to-day, and there is no better treatment than the use of compound worm capsules[17] containing extract of male fern. For *Raillietina* infestations tetravalent compounds of tin (butyl tin dilaurate) "Butynorate" capsules, 75 mg. per kg. minimal dose (Kerr 1952) are being used in America.

Roundworms

Piperazine, which is now being recommended for the treatment of large roundworms in poultry, was first used in man in 1949 (White 1954); its advantages are that no starvation is required, nor any purgative afterwards, and it is almost devoid of toxicity. Three preparations are available: piperazine adipate (Coopane[18]), piperazine bi-sulphide (Safersan[19]) and piperazine citrate (Pipricide[20])—the last mentioned can be given in the drinking water as it is soluble. Piperazine causes a progressive torpidity of the worms (without any initial phase of irritability) and does not have any adverse effect on egg production, either when mixed in the feed or given in the drinking water. "Safersan" is a complex between piperazine hexahydrate and carbon bi-sulphide. As both compounds have anthelmintic properties, and because Safersan can be mixed in the feed with phenothiazine, it possesses added advantages.

It is doubtful whether any of the piperazine compounds are effective against capillaria infestations unless given at a higher dosage rate, *e.g.*, ½ to 1 gramme per kilo compared with the 50 to 100 mg. per kilo normally used (Leiper 1955).

It is reported from the Agricultural University of Brno, Czechoslovakia (Klimes, 1954) that synthetic benzine is being used successfully for the treatment of turkeys and fowls suffering from ascaridia and taenia infestations. This remedy is inexpensive and does not interfere with egg production when given in doses of 2 c.c. per kg. bodyweight, but except for a possible application where the control of tapeworms is concerned benzine is unlikely to be used in this country.

Although 15 mg. of procaine penicillin was found by Todd & Stone (1952) to result in a reduction in the number of ascaridia present at *post-mortem* examination, compared with the numbers of worms recovered from untreated birds, it is unlikely that penicillin will be used as an anthelmintic.

16 "Barintar" Imperial Chemicals (Pharmaceuticals) Ltd.
17 Compound Worm Capsules (Willows & Co.)
18 Cooper's
19 Boot's
20 Burroughs Wellcome

Treatments for External Parasites

Lice

The revised edition (March, 1955) of the Ministry of Agriculture's Animal Health Leaflet No. 26 gives a most excellent account of the life history of most of the external parasites of poultry and should be read by everyone, but unfortunately not all practitioners will be in agreement with the suggestion that "dipping is the most effective treatment [for lice] using a tepid, water suspension" of the insecticide.

One of the latest methods does not involve handling the birds at all, nor does it put them off lay, and it is 100 per cent. specific for the common broad body louse (*Eomenacanthus stramineus*) which so commonly infests the vent area. This concerns the use of an electrically heated thermostatically controlled volatiliser[21] which is fastened to the wall of the poultry house. It consumes rather less current than a 60-watt electric light bulb, and one such unit generates an insecticidal aerosol of benzene hexachloride (or DDT) sufficient for the treatment of 100 to 200 infested birds in a room of 60,000 c.ft. capacity. The apparatus is left on night and day for a fortnight at the end of which time all evidence of external parasites will be gone, and in our experience no re-infestation has occurred after five months.

Another new and equally successful method for de-lousing poultry is to give each bird one capsule containing 50 mg. of the gamma isomer of benzene hexachloride by mouth. Attention was drawn to the possibility of such a method by the article by J. J. Wassenburger (1952) who used the oral method for treating infested pigs. As a fact, of course, most poultry farmers de-louse their birds by dusting them with powders containing sodium fluoride, DDT or gammexane; or alternatively by the use of nicotine sulphate—used either as a perch paint, or by direct application to the scales of the legs. But the necessity to re-apply the preparation in about 10 days' time to deal with any parasites hatching out is important, and often neglected, because it has been our experience that one application is insufficient to deal with these parasites.

For poultry kept on the deep litter system the method used by S. Moore (1954) in which a 1 per cent. lindane (gamma benzene hexachloride) dust was applied as a single application to the litter at the rate of 3 lb. per 1,000 sq. ft. is one which can also be expected to give a good result. It gave adequate control over *Eomenacanthus, Menopon* and *Goniocotes* species, and would certainly prove popular with farmers.

Note.—The mere presence of lice on laying stock, even in large numbers, is not necessarily of clinical significance. We have found for example that many of the better layers can be quite heavily infested without showing any symptoms, or suffering any apparent harm—a condition, in fact, somewhat similar to that relating to heavy infestations with caecal worms (Heterakis).

21 "Aerovap" (Shepherd's Aerosols Ltd.)

Mites

Scaly Leg

For years the common treatment for scaly leg disease in poultry was by dipping the bird's legs in paraffin or crude oil, or by the use of sulphur ointments, but there is little doubt that practitioners will nowadays prefer to recommend the use of more specific preparations containing, for example, benzyl benzoate, gammexane or tetraethylthiuram monosulphide ("Tetmosol"[22]).

Redmite and Northern Fowl Mite

Although nicotine sulphate preparations have been used successfully for dealing with redmites (*Dermanyssus*) in deep litter houses, or indeed anywhere where there are slats or perches, they have been much less successful against *L. sylviarum*. At the Tenth World's Poultry Congress, Edinburgh, 1954, Brander & Thomas reported the successful employment of low-pressure aerosol dispensers containing piperonyl butoxide/pyrethrins for treating Northern-Fowl-Mite-infested pullets in battery cages. The aerosol can be applied direct to the birds (in the area of the vent) and also to the adjacent parts of their cages; and it can also be used on five-week-old turkeys. On one farm in Bedfordshire a unit of 20,000 battery-caged pullets was successfully disinfested in this way, and there can be no doubt that this new and simple treatment will replace the older use of perch paints on many occasions.

Antibiotics as Poultry Meat Preservatives

One of the first reports on the use of antibiotics in low concentration for the preservation of flesh foods was that by Tarr *et al* (1952) in which the effectiveness of 14 antibiotics were tried out experimentally on fish and meat, aureomycin, terramycin and chloromycetin proving valuable. Rimocidin in conjunction with aureomycin restricted yeast growths; sodium nitrite was very effective when used at 4 to 20 times the concentration of the antibiotics. Laboratory experiments by Kohler *et al* (1955) showed that weak solutions of aureomycin were readily absorbed into the breast muscles of chickens when used at levels ranging from 3 to 1,000 p.p.m. Good preservation effects were noted on cut-up poultry, and also on carcases immersed for two hours in a cooling tank containing 10 p.p.m.; residual aureomycin was readily destroyed by ordinary cooking methods. *Food Investigation* (1954) mentions that antibiotics have been studied by the Department of Scientific and Industrial Research, for the preservation of flesh meats and fish preserved at chill temperatures.

Our own experiments have concerned the use of the tetracyclines by mouth (capsule), and in the drinking water, with a view to observing their effects on "greening." Greening is the result of natural decomposition which occurs readily in poultry carcases in warm weather. The discoloration effects the abdominal muscles and vent area, and is greatly objected to by the trade because of its unsightliness and the consumer prejudice which it creates in the minds of housewives.

[22] I.C.I.

Preliminary trials showed that one terramycin capsule (100 mg.) given six hours before killing prevented all but slight greening 48 hours after plucking had taken place. This was ineffective when starvation was not practised. Day temperatures ranged from 66° to 88° F., and night temperatures averaged 55° F.

In a subsequent trial on similar lines 50 mg. aureomycin proved somewhat superior to 100 mg. of terramycin, and of greater benefit still when used in the water-soluble form because of ease of administration (1 tablet to 1½ pints of drinking water). These experiments are continuing.

Summary

Great advances in poultry therapeutics have been made during the past 10 years, particularly where the use of antibiotics, "sulpha" and "nitro" drugs are concerned.

Antibiotics

Penicillin can be recommended for the treatment of staphylococcal and streptococcal arthritis, erysipelas in turkeys, fowl spirochaetosis and goose influenza; it also has a specific effect against *Cl. botulinum*. Penicillin can also be used for its synergistic effects with streptomycin in the treatment of infectious sinusitis in turkeys.

Streptomycin has specific effects against some salmonellae, haemophilus infections (coryza), quail disease, and *M. tuberculosis* infections; but the ease with which streptomycin-resistant organisms develop limits, amongst other things, its application to poultry. When single, intramuscular injections are being given, not less than 200,000 units per bird should be given.

Aureomycin and terramycin, now considered to form part of the "tetracycline" group of antibiotics, are also of great value for treating outbreaks of infectious sinusitis in turkeys, chronic respiratory disease in chickens and "blue comb" in turkeys. They have also been recommended for use against certain pasteurella and salmonella infections, but for the treatment of B.W.D. and fowl typhoid in particular the use of furazolidone is strongly recommended.

Chloromycetin has not as yet been used to any considerable extent in the poultry industry, but it is possibly the drug of first choice for treating outbreaks of fowl cholera, and it may also play a supplementary rôle in limiting C.R.D. infections.

No details have been included in this paper of the value of other antibiotics for which there are records of their limited application, *e.g.*, bacitracin, erythromycin, neomycin, magnamycin and polymyxin.

Brief notes on the following conditions, for which antibiotics are particularly recommended, have been given: aspergillosis, "blue comb" (turkeys), botulism, chronic respiratory disease (C.R.D.) (chickens), chronic coryza, erysipelas, exudative scepticaemia (geese), fowl spirachaetosis, infectious sinusitis, non-specific infections

in chicks and poults, pullet disease (chickens), quail disease and staphylococcal arthritis.

Antibiotic Feed Supplements

A résumé of antibiotic feed supplements, at both low and high-level dosages, is given, the use of the latter being recommended for cases where egg production has fallen for no obvious cause due to sub-clinical infections or other biological stress factors. Also for the supplementary treatment of hexamitiasis and roundheart disease.

"Sulpha" Drugs

The value of the sulphonamides for treating coccidiosis in chickens and turkeys is indicated. A note concerning so-called "haemorrhagic disease" and its relationship to the "sulpha" drugs is given.

"Nitro" Drugs

Nitrophenide is recommended for treating cases of intestinal coccidiosis in growing pullets; the toxic effects of nitrophenide are recorded.

Among the nitrofurans an account is given of the use of nitrofurazone for both the prevention and cure of caecal coccidiosis in chickens, as well as of its possible toxic effects.

Furazolidone and its relationship to the control of salmonella infections, blackhead and hexamitiasis are outlined briefly, as well as the use of the amino-nitrothiazole compounds for the control of blackhead in turkeys.

Other Drugs

Amongst the more modern anthelmintics reference is made to the use of barium antimonyl tartrate for the treatment of gapeworms, a tetravalent compound of tin for tapeworm infestations (*Raillietina*) and piperazine compounds for the treatment of large roundworm infestations (*Ascaridia*).

Some of the newer methods for treating poultry suffering from heavy infestations with lice, including the use of "B.H.C." by mouth, by volatiliser or by additions to the litter, are discussed.

Finally, there is mention of the successful employment of low-pressure, aerosol dispensers for treating pullets in battery cages suffering from Northern fowl mite infestations.

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THE SPEAKER'S INTRODUCTION

The Chairman, Dr. D. Luke, said Dr. Blount was known to most of them by repute, having gained an enviable reputation, where poultry were concerned as an interpreter of the scientific profundities. Dr. Blount had also had a great deal of experience in applying scientific knowledge to poultry keeping.

Dr. Blount: "My first point refers to the dosage of streptomycin. From the work of Bornstein and Samberg it is obvious that unless one gives 200,000 units as an initial dose there is a great risk of resistant strains at least developing. It should be emphasised that it is an advantage to give a full dose at the beginning. I do not know whether there have been any cases of toxicity from streptomycin in poultry through over-dosage and I should be interested to hear if others have heard of any.

"Bacitracin: We have only just used this and we did not find that it gave any increased growth rate. In the case of chickens, perhaps in contrast to turkeys, we have not found any combination of antibiotics has given a better result than procaine penicillin and in that connection we have found quite marked differences between different brands.

"'Sulpha' drugs: At a broiler conference held last week at Stratford the chief speaker emphasised very strongly the great success he had had in controlling caecal coccidiosis by using sulphamezathine at half strength with terramycin food supplement at the rate of 1 or 2 lb. per cwt. He was quite definite that he had controlled a very severe outbreak in 10,000 chickens in one house. Perhaps that supports American experience in which nitrophenide is used with Aurofac 2A as a high level feed.

"Sulphonamide poisoning: In my opinion it is absolutely wrong for the veterinary profession to use the word 'poisoning.' There is not the slightest indication that this so-called haemorrhagic diseases is the result of so-called poisoning. I am not a toxicologist—if Dr. Alexander is here he will probably define a poison—but to my mind a poison is something which, if given to a group of animals, will affect the bulk of them, all of them becoming affected if the amount is increased. That is not the case with this haemorrhagic disease. 500 birds in 20 folds can all be given the sulpha drug and the haemorrhage disease will break out in two or three places, perhaps in one pen eight out of 20 birds will die. It is not associated with any deficiency of vitamin K, and I should like to point out that we have just had a second outbreak in which the only dosage with sulpha drugs was given at least eight weeks previously. A group of birds suffering from coccidiosis were given the sulpha drug and 14 developed typical haemorrhagic disease. The trouble gradually disappeared and deaths ceased and the birds went on perfectly normally for eight more weeks then more birds died with the same haemorrhagic symptoms, but to a lesser degree. But cases of nephritis increased and the greatest pathological change is to be found in the bone marrow. It is pale and fatty, and bears no resemblance to normal bone marrow.

"So-called sulpha drug poisoning cannot be reproduced satisfactorily in the field with the normal dosage, but true poisoning can be induced with nitrofurazone. If the therapeutic dose is multiplied by about four (in the case of the turkey) or six to ten (in the case of the chicken) there will be very definite symptoms. I would suggest the symptoms differ according to the age of the bird.

"We have also experienced nitrophenide poisoning and in older birds the symptoms were almost identical with those caused by nitrofurazone. Turkeys are more sensitive than chickens to nitro drug poisoning.

"I should like to make a slight correction to page eight of the paper, lines 13 and 14, where it is stated 'All chicks that died were subjected to *post-mortem*.' That is not correct. The farmers concerned were invited to send all chicks. The percentages given refer to the chicks that were actually sent.

"Enheptin: It is important that the farmer should realise when he is using grain as a major feed that the amount of enheptin must be in proportion to the total feed intake. If up to the age of 12 weeks the birds are having an all mash diet and then change to mash and grain, it must not be thought that the dosage of enheptin is given only in relation to the mash.

"On page six there is a reference to Ni-carbazin, a new agent from the United States which is on trial in this country. It should not be used on any adult stock because it de-colourises the shells, the eggs being laid without any pigment.

"On page ten there is a reference to Barintar for controlling gapeworms in turkeys. The firm concerned no longer market this product and the pheasant rearing industry will not in future be able to get it, which seems to me to be a great pity.

"It has been suggested that phenothiazine might be used for controlling gapes. It will not cure the pheasant chick already affected but merely reduce the numbers of larvae and therefore subsequent infestations. I should be interested to know whether members have had any experience of new products in the control of tapeworms.

"Finally, 'greening' creates an entirely new use for antibiotics in low concentrations which may well prove useful in reducing the discoloration which takes place after killing and to which housewives, of course, have such a strong objection.

I should like to add to the paper the following list of proprietary names:" [*These have been added as footnotes to the Paper itself.*—Editor].

The Opener

The Chairman said that Mr. Wilson, who was going to open the discussion, was well known also to those interested in poultry diseases, particularly those interested in research on salmonellosis for which subject he enjoyed an international reputation.

Mr. Wilson said: "I would like to congratulate Dr. Blount on his most interesting paper in which he has succeeded in including all the recent developments in poultry therapeutics. I think he is wise in omitting references to biological products, which are of very limited use in this country. It is impossible in the time available to allude to all or indeed many of the valuable contributions described in the paper, even if that were desirable. I consider that the time can be used most profitably by concentrating on the more important developments, with a bias towards those of greatest interest to the practising veterinary surgeon, who may not always be fully conversant with modern trends in poultry husbandry and the disease risks associated with them, or to the existence of new and improved methods of control.

"In my view the reasons advanced by Dr. Blount for the neglect of diseases of poultry by veterinary surgeons in practice are sound. Why should a veterinary surgeon be criticised for not undertaking unremunerative work or be encouraged to do so? While there are many diseases that can be diagnosed without access to laboratory facilities, I believe that the better method is for the veterinary surgeon in practice to make increased use of the specialist laboratory, thereby not only obtaining a speedy and accurate diagnosis but also up-to-date information of the best methods of treatment and control, which he can pass on to his client. Without consultation it may not be easy to select the therapy most appropriate to a particular case. With modern methods of skilful advertising it is difficult to determine the relative efficiency of the competing drugs which may also vary under different systems of management, *e.g.*, certain products may be successful only against a limited weight of infection.

"A particular line of treatment may be economic under certain circumstances only, largely depending on the species and age of the stock to be treated.

"A recognised control measure may be impractical under some systems of husbandry. A drug which is successful under laboratory conditions when a knowledge of the time of acquisition of infection allows early treatment, may prove disappointing in the field through inevitable delays in application. Conversely the apparent success of a drug in the field does not necessarily provide a reliable indication of its true value. The laboratory should be in a position to offer advice on all these points.

"Whenever possible treatment involving the individual handling of birds should be avoided. Under present day conditions with larger farms and greatly increased size of units in which birds are housed, by hundreds and sometimes even

by thousands, the labour entailed in individual treatment is costly and unless it is known that a drug is specific for the condition present the bad effects of handling large numbers of sick birds often makes speculative treatment worse than none at all.

"In treating sick fowls drugs should be selected whenever possible which can be administered in the drinking water as in most diseases inappetence is a marked feature whereas thirst usually persists or may even be increased. When used for prophylaxis, drugs are probably better incorporated in the food.

"From Dr. Blount's survey I would select the following as the most outstanding developments in chemotherapy: the original observations of Levine (1939, 1941) which led to the use of sulphonamides for the treatment of coccidiosis, after valuable research at Weybridge and elsewhere; the discovery of 2-amino-5-nitrothiazole (better known as Enheptin in U.S.A. and Entramin in Great Britain) by Waletzky and his colleagues, which has proved a boon to turkey farmers everywhere in the control of blackhead; the reports of Stokstad and Jukes (1950) on the effects of the addition of aureomycin to the diet of chicks and the many ramifications which have followed this discovery; the synthesis of furazolidone by Stillman and Dod, later shown by Yurchenco and his colleagues to be active against grambacilli and the original observation by Harwood (1954) of its efficacy against fowl typhoid.

Antibiotics

"Dr. Blount has rightly devoted a large part of his paper to an account of the antibiotics of which penicillin, streptomycin, aureomycin and terramycin are most commonly used in poultry. The incorporation of small amounts of penicillin, aureomycin or terramycin in the diet of chicks or turkey poults kept under ordinary farm conditions almost invariably results in increased growth, particularly during the first few weeks of life. We found that the addition of penicillin to the mash (12 grammes to 1 ton) of turkey poults kept on a farm not only consistently stimulated growth but was effective in reducing mortality from nonspecific causes, whereas in birds kept in conditions of extreme isolation growth stimulation did not occur (Wilson 1953). This has been the experience of most workers.

"In this country the use of antibiotics has been mainly confined to treating erysipelas, infectious sinusitis of turkeys and the lung and air sac complications which often accompany it, and less commonly, staphylococcal arthritis of turkeys, all by injection, and pullet disease and respiratory infections in fowls, by administration in the food.

"According to Moynihan and Stovell (1954) penicillin is the antibiotic of choice in erysipelas. Treatment consists in injecting 100,000 units a day for four days or a single injection calculated on a 4 day basis. Terramycin may be used at the rate of 50—60 mg. per kilo body weight. Only about 30 per cent. of treated birds developed any immunity and focal infections were found a month after treatment in 20.0 per cent. of the birds which had received terramycin and in 5.3 per cent. of these which had received penicillin. The value of streptomycin was doubtful even when given at four to five times the rate of penicillin. A single strain of *E. rhusiopathiae* was found to be resistant to penicillin.

"Dr. Blount described several methods of treating infectious sinusitis of turkeys and I would agree that it is sometimes necessary to switch from one antibiotic to another. We have found that a combination of streptomycin and penicillin is superior to streptomycin alone. Crawley and Fahey (1955) have confirmed that this is also the case in chickens affected with CRD. The lung and air sac complications in sinusitis are often serious and we have noted a speedy improvement in health following treatment, and increased egg-production, and higher fertility and hatchability. Terramycin in oil is also useful.

"Sometimes antibiotic treatment of respiratory disease is disappointing and even repeated injections may fail. Recovered birds appear to possess little if any immunity and exacerbations of symptoms are not uncommon. Cover (1954) treated nearly 20,000 birds with terramycin in oil, terramycin in drinking water and streptomycin intra-muscularly and observed little difference in the mortality of treated and control pens.

"In our hands the feeding of high levels of antibiotic supplements has failed to prevent the occurrence of respiratory diseases and has often done little to alleviate the symptoms.

"Here I must take up Dr. Blount on his statement that his results, although satisfactory to the farmer would not impress a research worker! He is perfectly correct. We must distinguish clearly between the objectives of treatment and experimentation. In the former the final result is the criterion of success and recovery however it is achieved is highly gratifying to the veterinary surgeon and the owner, but it must remain at that.

"In critical experimentation everything must be standardised, with the absence or presence of the drug the only variable, before any claim for the effectiveness of a particular treatment is justifiable. The assessment of a drug from the results of flock medication in the absence of adequate controls can be most misleading I am not suggesting that antibiotic treatment is not successful, but the high percentage of birds in control pens in which spontaneous recovery or remission of symptoms occur is often surprising. Without controls the improvement would naturally be attributed to the effect of treatment.

"I am rather sceptical of the value of antibiotic supplements in the treatment of hexamitiasis. Inappetence is so early and so complete in the acute disease that a drug administered in the drinking water would have much greater chance of success. Of all the drugs tried we have found 2-amino-5-nitrothiazole in the drinking water to be the most successful (Wilson & Slavin 1955). Di-n-butyltin dilaurate (Tinostat) is reported to be successful in preventing the disease (Salsbury 1953).

Sulphonamides

"I agree with Dr. Blount on the value of sulphamezathine and sulphaquinoxaline in the treatment of acute caecal coccidiosis. There is little to chose between them; sulphaquinoxaline is more palatable and on that account is to be preferred for turkeys and pheasants. The recommendation of Davies and Kendall (1954) that the drugs be given for three days, miss two days and treat three days should always be followed. While I can confirm the beneficial effect of continuous feeding of sulphanquinoxaline (0.0125 per cent.) in the mash in preventing coccidiosis in both chickens and turkeys, I would hesitate to recommend wholesale continuous feeding of any drug, as a method of disease control.

"The curious effects which sometimes follow treatment with sulphamezathine and sulphaquinoxaline are most puzzling and search for an explanation has provided one of the most intriguing problems we have ever investigated. We have seen the condition twice at Lasswade, first in 1950 when its possible association with sulphonamide therapy was not appreciated and again a few months ago, when only a single pen of birds was involved. During the intervening years we have consistently failed to reproduce evidence of toxicity by overdosing, continuous and repeated treatments or with diets deficient in vitamin K. Our colleagues at Weybridge have been more successful in reproducing the condition. The age of chicks appears to be an important predisposing factor. Under experimental conditions chicks four to six weeks old are more sensitive (Davies 1954); younger chicks are less easily poisoned but chicks up to eight to ten weeks may be affected.

"Differences in diet may sometimes play a part but I agree with Dr. Blount that the condition does occur when normal levels of the drugs are used and under conditions which preclude any possibility of deficiency of vitamin K.

"In an unpublished paper Joyner and Davies (1955) report that while the administration of vitamin K reduces the blood clotting time of birds receiving sulphaquinoxaline it has no effect on the lesions. Failure to reproduce the disease in the laboratory is not unexpected and is consistent with experience in the field where during the past few years many millions of chicks have been successfully treated with untoward results in only a few cases. At Lasswade, we investigated 40 cases in 1953, 18 cases in 1954 and 19 cases in 1955. It is probable that the more general use of the method of dosing recom-

mended by Davies and Kendall is responsible for this significant decrease.

Nitrophenide and Nitrofurazone

"In our hands nitrophenide and nitrofurazone have been markedly inferior to sulphamezathine and sulphaquinoxaline in the treatment of acute caecal coccidiosis of chickens. We tend to regard the latter drugs as standards with which to compare the efficiency of other coccidiostatic drugs.

"In one experiment in which 90 per cent. of untreated birds died, there were mortalities of 64 per cent. and 38 per cent. in groups which received nitrophenide, 0.05 per cent. and 0.10 per cent. respectively and a death rate of 36 per cent. in a group treated with nitrofurazone 0.018 per cent. There were no deaths in chicks which received sulphamezathine 0.2 per cent. In each case treatment began 48 hours after infection. When treatment was delayed until 72 hours after infection there was no significant difference in the mortality of chickes receiving 0.018 per cent. nitrofurazone and that of untreated controls and again there were no deaths in the pen treated with sulphamezathine 0.2 per cent. (Wilson 1952). The results of Willems, Vanschoubroek and Vercruysse (1954) with nitrophenide (0.0125 and 0.0187 per cent.) must be considered as very inferior to what might have been expected with either sulphamezathine or sulphaquinoxaline.

"Although Horton Smith and Long (1952) found nitrofurazone 0.011 per cent. to be an effective coccidiostat, in one of their experiments there was a mortality of 40 per cent. which was thought to be caused by improper mixing of the drug. Davies and Kendall (1955) found that at a level of 0.0196 per cent. in the mash it was considerably less effective than sulphamezathine 0.2 per cent. Even when treatment preceded infection, nitrofurazone had no significant effect on the mortality which followed dosing with 50,000 or 200,000 oocysts. They do not consider that continuous medication with nitrofurazone is likely to prevent the appearance of an epidemic under field conditions for in their experience the drug is not only therapeutically ineffective against active disease but when used in this way it may actually accentuate the severity of an outbreak. In their view the drug has a marked effect on relatively mild infections and might lead to an appreciable improvement in growth.

Furazolidone

"Dr. Blount has referred to the work of Williams Smith (1954, 1955) with furazolidone, a drug which was expected to be of value chiefly against blackhead until Harwood (1954) showed that it controlled a serious outbreak of fowl typhoid in turkeys in which the mortality in untreated controls was 100 per cent. We have had a fairly extensive experience with this drug, both in natural outbreaks of fowl typhoid in the field and in experimental infections in chicks with *S. pullorum, S. gallinarum S. typhi-murium* and *S. thompson*. It has been particularly successful in the artificially produced disease in which it has been possible to start treatment within 72 hours of infection. At a level of 0.04 per cent. in the food it has prevented deaths and almost completely eliminated carriers in the treated stock; in untreated control pens mortality has been as high as 100 per cent. At lower concentrations breakdowns occur after treatment ceases. When treatment is delayed, as it inevitably is in the natural disease, results while less spectacular are still highly successful, and greatly superior to those obtained with sulphonamides (Wilson 1955).

"We have been unable to confirm the results of Gordon and Tucker (1955) with adult 'carriers,' which Dr. Blount quotes. In our hands the same treatment has not resulted in a significant fall in titre, and foci of infection have almost always remained. Treated birds however invariably cease producing eggs which contain salmonella.

"The drug is likely to be of greatest value in controlling fowl typhoid for which all efforts to produce an effective dead vaccine have been unavailing, and in the treatment of salmonellosis of chicks and turkeys.

2-Amino-5-Nitrothiazole

"Little need be added to Dr. Blount's remarks on this drug which has proved of inestimable value in the control of blackhead in all parts of the world.

"The observation that deaths from blackhead occur after treatment ceases is not new; it was noted as long ago as 1950 by Waletzky, Clark and Mason. De Volt, Tromba and Holst (1954) found that poults receiving the drug at the 0.05 per cent. level might still harbour Histomonas and that treated birds were on average as susceptible to re-exposure as untreated birds.

"In a very valuable paper Joyner and Kendall (1955) reported that treatment with 2-amino-5-nitrothiazole at 0.1 per cent. for 14 days nearly always effected permanent suppression of *H. meleagridis* if it was started at or before the time of infection. If treatment was delayed for more than 24 hours after infection or the drug was used at a lower concentration relapses were liable to occur after treatment stopped. Continuous administration at the 0.05 per cent. level was recommended, or for the control of established outbreaks a course of treatment at the 0.1 per cent. connectration followed by continuous treatment at a level of 0.05 per cent.

"Stabler and Mellentin (1953) showed that 2-amino-5-nitrothiazole (28 mgms. per kilo bodyweight for 7 days) is effective in the control of *Trichomonas gallinae* in pigeons (canker). Successful results have been obtained in this country by administering the drug in the drinking water at up to twice the concentration recommended for turkeys.

External Parasites

"I do not propose to comment on the treatments of external parasites beyond saying that I think it is unfair of Dr. Blount to misquote the sentence on dipping fowls as a method of delousing, in the Ministry's Animal Health Leaflet No. 26. Anyone unaquainted with the real position would somewhat naturally conclude from his paper that this is the recommended method of choice, whereas in the leaflet the usual procedures are given priority and then at the end of the account comes 'Dipping is the most effective method *but should only be employed as a last resort.*' This places quite a different complexion on the matter.

"In closing I would join Dr. Blount in paying tribute to the research workers through whose efforts a range of valuable drugs is now available for some of the major diseases of poultry. There are differences of opinion as to how they should best be used. Although there are circumstances that justify their continuous administration in the food, wholesale use in this manner appears to be undesirable and poultry farmers should be discouraged from regarding medicaments as essential components of the normal diet.

"Good hygiene, husbandry and nutrition are fundamental; the growing tendency of some poultry farmers to regard drug and vaccine therapy as substitutes is regrettable."

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The General Discussion

Dr. Elder (Stormont) said that, as a medical man, he was very much impressed on hearing Dr. Blount and reading his excellent paper. The paper showed how far therapeutics by way of drug and antibiotic applications had been used in veterinary science. Veterinarians had the advantage in that they could employ mass therapy in a way that could not be used in medicine. At the same time, medical men made use of animal experimentation. Some two or three years previously Dr. Elder had been engaged in the study of poliomyelitis in human beings, and that was instrumental in his writing a paper which eventually brought forth a communique from Vancouver regarding poliomyelitis in Eskimos which was thought to be the result of their eating dried egg powder. Professor Lamont had said there was no connection between the virus of poliomyelitis and the virus of fowl paralysis. There was, however, no definite answer except serologically. One was struck later by the occurrence of cases of a virus which occurred in people who kept poultry which had been suffering from glucosis or paralysis. It was not being suggested that there was any connection scientifically but, at the same time, had veterinary science used any drug which in any way affected fowl paralysis? It was possible that one of the three types of poliomyelitis viruses might conceivably cause a condition in an animal or bird which might cause the virus to lose virulence and which in the human being might produce not more than an upset of metabolism.

Dr. Elder wished to express his best thanks to the British Veterinary Association for extending an invitation and welcome to people like himself to attend the Congress. It had been a most stimulating and enjoyable week altogether. He hoped it would not be too long before the Congress returned to Belfast.

Dr. Blount said that to suggest that Professor Lamont did not know what he was talking about was nonsense. He himself could not speak on poliomyelitis. In fowl paralysis it was not usual to try any treatment. Treatment was tried in the '30s and the only treatment that was successful was injections of pot. iodide as used by Ernest Gray.

Mr. W. A. M. Gordon (Stormont) congratulated Dr. Blount on his paper, which was something that had been needed for a long time. It would be a very useful reference not only for the veterinary profession engaged in poultry work, but to an even wider field of veterinarians. Had Dr. Blount experienced increasing cases of coccidiosis in chickens which were being given NEFCO prophylactically?

Regarding tapeworms, at Stormont they had used tenoban and felt it very useful. Quite satisfactory results had been obtained in cases of renal coccidiosis with sulphamezathine.

In the matter of nitrofurazone poisoning, Mr. Gordon had experienced a rather interesting case among growing birds on an experimental farm run by a miller who accidentally over-medicated some meal for experimental birds. It was noticed that not only did the growing birds show symptoms of toxicity, but also crows which ate some of the meal. The matter was being followed up. Samples of mash were taken but no result could be given yet.

Had Dr. Blount experience of treating bumblefoot in birds with streptomycin? Streptomycin appeared to give quite satisfactory results.

Dr. Blount said he had not experience of an increase in coccidiosis as suggested. Surely the oocysts had not been encountered or else there would have been a natural immunity? He was very glad to know sulphamezathine had been satisfactory in treating renal coccidiosis. He had not had the opportunity of treating bumblefoot with the antibiotics, streptomycin in particular, but certainly one would think they might be of value. Would Mr. Gordon say whether there had been any surgical interference at the time of the streptomycin treatment?

Mr. Gordon said that in bumblefoot surgical procedure had been abandoned by his co-workers as it seemed to do more harm than good. The cases were treated with ½ gm. of streptomycin, repeated at daily intervals for three days in all the bad cases. In mild cases there was often a response after one treatment.

Dr. Blount asked if the treatment had been intramuscular or local.

Mr. Gordon replied that it had been intramuscular.

Dr. E. L. Taylor (Weybridge) said he would like to ask Dr. Blount to explain one or two general points, with particular reference to his conclusions from clinical trials. In the section of the paper dealing with nitrofurazone the conclusions were arrived at as a result of the lack of complaints. It amounted to a statement that one million chickens could not be wrong! The birds were receiving the drug in the form of a medicated diet and there were no complaints. They had all known, of course, of widely-used substances which ultimately proved to be of no value at all. Dr. Taylor agreed that nitrofurazone was a very effective coccidiostatic drug but he maintained that a clinical trial alone proved very little, and if one went on lack of complaints, one could have come to the conclusion that "Yadil" must have been a most excellent medicament. Controlled experimental results seemed to be of infinitely greater value than field observations of that kind. It was a most difficult matter to run a controlled observation in the field so the controls were usually left out. One did not then know what would have happened had the drug not been given.

Perhaps to some extent they all believed in magic and mumbo-jumbo and when something new came out and was said to be excellent, unless one had a critical turn of mind, one was rather apt to think it must be true. The sort of evidence that had been given on nitrofurazone was not necessarily of very great value. It would be interesting to hear Dr. Blount say a little more in support of clinical trials.

Dr. Taylor wished to refer next to premedication, which he had not heard discussed at all widely. It had come to stay, there seemed no doubt about that, and some of them felt a little afraid about where it might lead. The vendors of foods could be mixing all kinds of things with foods and advertising that it would cure this disease or that when perhaps there was no foundation for the claim. On the other hand, he agreed that it might be a very good thing, if there was to be any pre-mixing done or any medication of food at all, that it should be in the hands of responsible people who were selling foods rather than for the farmers to try to do it for themselves.

Dr. Elder had suggested that wholesale medication could not be carried out for the human population, but of course it was done with regard to adding small amounts of iodine and fluorine to the salt, and that was a method that could be extended if necessary.

Again with reference to nitrofurazone and its administration with food, a few controlled experiments had been carried out at Weybridge with that substance mixed at various levels with the food and it was found that if the concentration was above a certain minimum, although coccidiosis would not develop while the birds were having the drug, it would develop soon after the administration ceased. The reason for that was that if the concentration of the drug was sufficiently high to prevent the development of the schizots in the wall of the gut it prevented the acquisition of immunity by the bird before the administration of the drug was withdrawn. In these instances on the withdrawal of the drug the parasites already present in the gut wall resumed their development and the chickens died of coccidiosis. That was one of the dangers of premedication. The chickens might remain all right while receiving a good daily dose of the drug, but if that treatment ceased cocciodiosis broke out soon afterwards unless the daily dose was below a certain

minimum concentration. In that way premedication might be adding to the danger instead of controlling the disease.

Dr. Blount said he understood the last point to be that if nitrofurazone was used at too high a level it would not allow of the development of immunity. Did that not apply to any such drug used at too high a level?

Dr. Taylor interjected that he was referring to the medicated ration.

Dr. Blount said that the same thing applied to any drug used in the wrong concentration. "Yadil" was used at the time of T.B. outbreaks in the 1920s, and was used in a hospital in Manchester. It was attacked by a national daily newspaper; but nobody proved that "Yadil" was useless.

With regard to controlled experiments, what were they? They were thought to be indicative of what took place in the field, which was sheer nonsense. Controlled experiments were not indicative of what took place in the field. Dr. Blount would say what was his belief regarding coccidiosis in the field. Oocysts being microscopic, a very young chick could take in so many at one bite that it had not sufficient sulpha drug or any other drug to counteract the large numbers of oocysts ingested. As the chick got older it could take in more drug. It was a question of two things: the number of oocysts that were available and the number taken into the system. If too small a number was taken in there was no immunity. If it were possible to arrange for the right number to be taken in there could be 100 per cent. immunity.

In Britain food was premedicated. It usually contained low levels of nitrofurazone. Presumably there must be some relationship between the amount of the drug and the number of oocysts and the one balanced the other and allowed the immunity to take place. If there was too much of the drug there would be no immunity. In the field, conditions varied from farm to farm and from pen to pen. Coccidiosis broke out here and there among birds under the same management. In a particular pen one bird would die but the others would not. By the inclusion of drugs in the feeds deaths from coccidiosis could be reduced and that was what they were concerned with in the field. It did not matter which drug was used so long as, in the end, the farmer had more live birds.

It was, then, a question of the cost of keeping deaths down, and at the moment nitrofurazone was the best drug to use. If anyone could bring along a better one it would no doubt finds its right place. Premedication was a matter of economics. The manufacturer of the feed had not the slightest interest in the drugs because he did not make any money from them; he was interested in selling the best feed to the largest possible number of customers. The farmer was concerned with keeping deaths down to the lowest level by any means at all. The practice in the country at the moment was to premedicate to keep down mortality. When coccidiosis appeared it was treated with one of the sulpha drugs and the total mortality was then well under 10 per cent. There was no question of a profit being made out of the drugs, but the farmer was better off in the end in having more birds alive.

Mr. H. E. Harbour (Berkhamsted) said that he wanted to join in the discussion on the value of clinical trials. He believed the clinical trial had a very important place, as had the laboratory experiment. It would be a pity if the audience went away under the impression that the only place where controlled experiments were done was the official laboratory. That was certainly not true. No doubt every reputable manufacturer, before releasing a new drug on the unsuspecting public, first of all carried out controlled trials in his laboratory and then surely put it to considerable clinical trial. Then if he was satisfied he sold it. The blood was on his own head if it failed because the farmer could be very critical.

An example of a controlled and carefully regulated field trial was one carried out a few years ago on maggot fly, in which the person concerned proved statistically that "DDT was not better than nothing." At the time there were some 10 million sheep in the country being treated with DDT preparations to the complete satisfaction of the people who bought them.

There was a place for both types of experiment. To some extent the control trial selected one set of circumstances, whereas in the field when something was being applied to a million birds the project was being tested under a variety of circumstances. Certainly the large-scale clinical trial was of value.

In the final sentence of the summary of the paper there was a reference to low-pressure aerosol dispensers for treating pullets in battery cages. It seemed necessary to mention that those dispensers should contain insecticide. "Aerosol dispensers" was too vague a term.

Mr. W. T. Harrow (Manchester) said that he hesitated to interpose in a discussion between two such eminent authorities as Dr. Taylor and and Dr. Blount but he wanted to go back to the nitrofurazone story. With regard to high level dosage and its inhibiting effect on schizot production, some feeding stuffs compounders were tending to put more than the recommended amounts of nitrofurazone in their mashes. That, of course, would produce this inhibiting effect and ultimately get nitrofurazone a bad name.

The other point was that Dr. Blount had suggested putting molasses with sulphamezathine to make it more palatable. That might possibly be a good thing for turkeys, but with poultry it seemed that if molasses were added it would probably lead back to the trouble of too much of the drug being taken.

Dr. Blount said he would like to put to Dr. Taylor one point on the question of using sulphamezathine in solution at an agreed level. Let it be assumed that the level was 0.2 per cent. Was it the concentration which reached the oocysts in the region of the caecal tubes which was the important point, or the total quantity passing through the gut in 24 hours?

Dr. Taylor did not know that he was qualified to give an exact answer. It was a matter of the presence of sulphamezathine in the blood of the chicken in adequate quantity to inhibit the development of the second generation of schizots but being not sufficient to inhibit the first generation. Going back to controlled experiments it seemed that Dr. Blount did not give a fair account of a controlled experiment and what it was. He had not in his reply referred to the necessary uniformity of experimental animals, a most important requirement. Since the result depended on the development of immunity by the chicken, it was most important to know that the chickens were susceptible to begin with. They must, for this purpose, be reared under very artificial conditions in order to maintain them free from infection. It is only by so doing that unknown variables are excluded, and observed differences between groups can be attributed to one cause. These conditions did not apply in the case of the pens described by Dr. Blount, because it was not known whether some circumstance had not resulted in a certain pen building up a bigger infection than another.

Miss O. Uvarov (Cobham) wanted to add her own quota of thanks to Dr. Blount and Mr. Wilson. Whether veterinary surgeons did or did not pay attention to poultry diseases was up to them, but what did matter was that the paper had been published with all the excellent information it contained and a list of references which was extremely useful.

The paper stated that organisms developed resistance to streptomycin quite quickly, and that was a well known fact, particularly in chronic diseases. In the past two disadvantages were attributed to streptomycin—firstly, veterinary surgeons had in the early stages been afraid of its use because of its toxicity and lately they were afraid of the possibility or organisms acquiring resistance to it. Were organisms likely to develop resistance to streptomycin so quickly under the conditions in which it was used for poultry work? If it was used for only a few days in recommended doses was resistance likely to develop?

Dr. Blount believed that Bornstein and Samberg emphasised that resistance was likely within two or three days unless the dosage was 200,000 units. It was found that resistance strains did develop very quickly. That was the only reference of which he knew.

Major J. H. Wilkins (Aldershot) said that no mention had been made of sulphadimidine. Was it used against coccidiosis?

Dr. Blount said he would like to refer that question to Dr. Taylor.

Dr. Taylor said that he had no information available.

Director Woldike Nielsen (Denmark) said that page six of the paper referred to sulpha drugs and the haemorrhagic syndrome. Did the haemorrhagic disease seen after treatment with sulpha drugs give different cultures similar to Newcastle disease?

Dr. Blount said that it did. Some cases of haemorrhagic disease were characterised by haemorrhages of the ventriculous, where it joined the gizzard, and if that only was found one might well confuse it with Newcastle disease.

Dr. R. F. Montgomerie (Beckenham) said that he would not be at all satisfied that there was any real relationship between the dose of oocysts taken in and the result of the administration of any of the drugs. Surely the objective in coccidiosis was to allow infection to take place and spread and then to control it by drug treatment so that the group of chicks was left immune. He could not help but feel in caecal coccidiosis the attaining of immunity was at least as important as the prevention of loss by death in any outbreak. They were all quite famliar with an outbreak of coccidiosis disappearing after the excessive use of some preparation early in an outbreak only to return in a very virulent form a little later. The whole objective had got to be two-fold. They must find the level of dosage which dealt with both aspects.

Dr. Taylor was quite correct in saying they should base their information first on true experimentation, starting off with completely susceptible birds, going on to the stage at which they had caused inspection, then to the stage of dealing with the outbreak. But surely they could never stop at the experimental stage? It was true that the action of the drugs was to interfere with the metabolism of the parasite. The work must then go into the field to make sure that the metabolism of the parasites was interfered with in the various sets of circumstances which were met with in the field. It was very nice to go to Weybridge and see the excellent experimental set-up there. But then one visited a broiler house and wondered how results obtained experimentally could be applied to a mass of 1,000 birds kept under very different circumstances.

Dr. Montgomerie hoped he had succeeded in putting a foot into both camps. The type of work done at Weybridge was quite fundamental and quite essential, but it would be the greatest mistake to think that results of experiments could be taken out and applied directly in a general way. There were some systems of management under which the experimental results could not be applied.

Dr. Blount said they must distinguish clearly between coccidiosis attacking chickens in broilers and attacking other chickens. In the broiler house there was not the slightest interest in immunity; all that was wanted was the same number of chickens going out after twelve weeks that went in. On the other hand, they were anxious that all other poultry should be prevented from having the disease in clinical form. In the broiler industry immunity might not come into the picture at all.

Reverting to controlled experiments, it was not Dr. Blount's idea of a controlled experiment to contrast two administrations of drugs, one in the drinking water and the other in the food, when there was no indication as to the amounts of water and food consumed.

Dr. Montgomerie said that surely all the drugs they were using had some influence on metabolism, the parasite's and the animal's. The drugs were being used at the level where they had reason to believe that the adverse effect on the metabolism of the parasite was going to be so advantageous that it would well outweigh the effect on the metabolism of the host. It might be wrong even in a broiler house to continue drug treatment because of the effect produced on the metabolism of the bird itself, when by using the drug properly at intervals one reduced the metabolism of the host, prevented clinical coccidiosis and established immunity. The cost of feeding the drug was important and the adverse effect it might have on the metabolism of the host were things which must be borne in mind. They were not using the old sort of therapeutic remedy; they were using drugs which interfered with metabolism. Personally he would prefer to see them always used at the lowest level necessary, so that immunity was achieved, the drug discontinued and caecal coccidiosis forgotten.

Mr. J. E. Wilson said he wanted to make it clear that he had not been criticising clinical trials but the absence of trials in the true sense of the term. In his view there could not be a proper clinical trial unless there was adequate control, irrespective of whether the experiment was in the laboratory or in the field.

The Chairman said that the discussion had unfortunately to be drawn to a close. On behalf of the meeting he offered their very best thanks to Dr. Blount, to Mr. Wilson and to all those who had contributed to the discussion.

Delegates to Congress

As in other years, the Association had the privilege of receiving a large number of special delegates at the Congress. The full list is as follows:—

Government Departments

Ministry of Agriculture, Fisheries and Food
Mr. J. N. Ritchie, C.B, Chief Veterinary Officer; and Mr. A. D. J. Brennan, C.B.E., Deputy Chief Veterinary Officer.

Ministry of Health
Dr. J. M. Ross, Senior Medical Officer.

Department of Agriculture for Scotland
Department of Health for Scotland
Mr. James Reid, Superintending Veterinary Officer.

Ministry of Agriculture, Northern Ireland
Mr. H. L. McConnell, Chief Veterinary Officer; Mr. D. C. Greene, Deputy Chief Veterinary Officer; Professor H. G. Lamont, O.B.E., Director, Veterinary Research, and Dr. W. R. Kerr.

Colonial Office
Mr. R. J. Simmons, C.M.G., C.B.E.

Ministry of Health and Local Government, Northern Ireland
Dr. A. T. Elder, Deputy Chief Medical Officer.

Department of Agriculture, Dublin
Mr. P. Harnett, Deputy Director, Veterinary Services, Professor J. A. Nicholson, Principal, Veterinary College, Mr. J. F. Timoney, Director, Veterinary Research, Mr. P. Crowley, Mr. D. F. McCarthy, Mr. J. Nowlan, Professor P. A. McGeady, Mr. M. G. Hynes, and Dr. L. B. O'Moore.

R.A.V.C.
Colonel L. W. Coulden, and Major J. H. Wilkins.

Overseas Representatives

American Veterinary Medical Association
Colonel Norbert A. Lasher, and Dr. C. K. Mingle.

Australia, High Commissioner
Australian Veterinary Association
Mr. L. N. Thornton, Commonwealth Veterinary Officer.

Canada, Department of Agriculture, Ottawa
Dr. R. J. McClenaghan, Chief Veterinarian (Contagious Diseases).

Canada, High Commissioner
Sir Frank Ware, C.I.E.

New Zealand Veterinary Association
Mr. W. M. Webster.

Norwegian Veterinary Association
Dr. Helge Baggerud.

Holland
Mr. E. de Nooy, Vice-President, Dutch Veterinary Association.

Iraq Veterinary Association
Major C. R. Chadwick, O.B.E.

Kenya Veterinary Association
Mr. J. W. Macaulay.

World Health Organisation
Food and Agriculture Organisation
Mr. N. R. Reid, M.B.E.

Yugoslavia, Union of Veterinary Associations
Mr. R. Vujovic, Vice-President.

University of Belgrade, Veterinary Faculty
Professor J. M. Dimic.

Local Authorities

City of Birmingham
Mr. C. G. Allen.

City of Cardiff
Councillor W. Groves, Deputy Lord Mayor, and Mr. J. H. M. Hughes.

Corporation of Glasgow
Bailie George Robertson, and Mr. S. G. Abbott, M.B.E.

Corporation of London
Mr. E. F. McCleery.

City of Manchester
Councillor Hinderer, Councillor Murray, Councillor Siddall, Councillor Bailey, and Mr. D. E. Orr.

City of Portsmouth
Mr. R. Scourlar.

Borough of Preston
Mr. F. J. Proctor.

Corporation of Dublin
Mr. J. M. Murphy.

The Universities

Edinburgh
Professor W. M. Mitchell, Director of Veterinary Education, Royal (Dick) School of Veterinary Studies.

Students' Union

Liverpool—Veterinary Society
Mr. S. Barrett.

Dublin—Veterinary Students' Union
Mr. P. J. Hartigan.

Edinburgh—Veterinary Students' Committee
Mr. P. Lamont.

Glasgow—Students' Union Society
Mr. R. G. Dalton.

London—Students' Union Society
Mr. K. C. Barnett.

Other Organisations

Agricultural Research Council
Dr. R. Scarisbrick.

Milk Marketing Board
Mr. G. F. Smith, Chief Veterinary Officer.

Visitors

Dr. Van den Born (Holland), Professor L. C. Moss (U.S.A.), Professor R. N. Hazarika (Assam Veterinary College).